Report No. FHWA-RD-76-111

REVIEW OF CURRENT AND PROPOSED LOW COST FREEWAY INCIDENT MANAGEMENT SYSTEMS

MAY 1976

Interm Report

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Prepared for

FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Washington, D.C. 20590

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Technical Report Documentation Page

1. Report No. FHWA-RD-76-111	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Review of Current and Proposed Low Cost Freeway Incident Management Systems		5. Report Date May 1976
		6. Performing Organization Code
7. Author(s) J. Bruggeman, G. Urbanek, J. Owen and C. Abrams of JHK & Associates		8. Performing Organization Report No.
9. Performing Organization Name and Address Peat, Marwick, Mitchell & Co. 1025 Connecticut Avenue, N.W. Washington, D.C., 20036		10. Work Unit No. (TRAIS) 31C2-512
		11. Contract or Grant No. DOT-FH-11-8813
12. Sponsoring Agency Name and Address Federal Highway Administration U.S. Department of Transportation Washington, D.C., 20590		13. Type of Report and Period Covered Interim Report September 1975 - April 1976
		14. Sponsoring Agency Code

15. Supplementary Notes
FHWA Contract Manager; S. Tignor, HRS-33

16. Abstract
This research report was prepared as an interim report for contract DOT-FH-11-8813, entitled "Alternative Surveillance Concept and Methods of Freeway Incident Management". The results of an in-depth review and preliminary analysis of the state-of-the-art of various minimum investment, low technology, freeway incident management systems are presented in this report. This effort included an extensive literature review and interviews conducted with interested agencies working in the freeway incident environment. In addition, a number of on-site incident investigations were conducted and 15 videotaped incidents were studied. The interviews and the on-site and videotape investigations provided the basis for the structure of six candidate freeway incident management systems, which are organized along functional lines. The detection, administrative, organizational, preplanning, and traffic control options of each of the candidates are presented with respect to their costs, characteristics, effectiveness, remedial potential, and several option-specific issues. Finally, data are presented to suggest a particular option effectiveness as compared with the total universe of all incidents.

17. Key Words Freeway Incident Management Motorist Aid Systems, Incident Data, CB Radio, Service Patrol, Call Box, TV Surveillance, Loop Detectors, Freeway Surveillance Concepts		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 179	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGEMENTS

Peat, Marwick, Mitchell & Co. (PMM&Co.) acknowledges the assistance and guidance received from Dr. Samuel Tignor, the Contract Manager for the Federal Highway Administration (FHWA). PMM&Co. also acknowledges the contributions of the various Federal, state, and local agencies to the initial stages of the project. PMM&Co. wishes to make special acknowledgement of the efforts of the Project Steering Committee, listed below, who provided valuable technical review of the draft materials: Lyle Saxton, Arthur Carter, Juri Raus, and David Merritt, all of the FHWA; Richard Frederick of the National Highway Traffic Safety Administration; and Norman Darwick and Arthur Smith of the International Association of Chiefs of Police.

OVERVIEW

This is an interim report pertaining to the research study "Alternative Surveillance Concepts and Methods for Freeway Incident Management." The purpose of the interim report is to present the current state-of-the-art in freeway incident management. Emphasis is placed on discussing the current practices used by operating agencies in detecting and responding to freeway incidents. Candidate minimum investment surveillance and detection methods are also discussed; however, no final recommendations for given systems are made in this interim report. The final report, which is not expected before July 1977, will present guidelines and recommendations on how operating agencies can select and implement alternative surveillance and detection methods for freeway incident management.

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CHAPTER 1

INTRODUCTION TO FREEWAY INCIDENT MANAGEMENT

INTRODUCTION

Freeway incident[1] management (FIM) has become recognized in recent years as one of the most important issues of urban traffic operations and control. Inflation, environmental concerns, and land use policies have virtually halted the urban freeway construction program and energy considerations have dramatically affected freeway operations. Therefore, it has become increasingly important to maximize the operational efficiency of the existing facilities.

Many urban freeways operate at or beyond their original design capabilities, at least during peak periods. The occurrence of an unscheduled event or incident may have serious deleterious consequences on highway performance over an extended period of time. Although a significant amount of research has been conducted on "high-technology"[2] approaches to incident detection and control, particularly in major urban areas containing high density freeway systems, alternative shorter-range, lower-cost approaches to the problem are also required. In fact, these latter may have a more widespread, immediate application in the great majority of urban areas.

In the past, the economic justification for incident management has focused mainly on two issues: the "direct costs" of an incident, expressed in terms of injury and property damage costs caused by accidents; and an allocation of a monetary value to the large amount of time delay of other vehicles, not directly involved in the incident, but delayed by it as a result of increased congestion. These factors have served also as two of the basic justifications of most previous planning and economic analyses of urban transportation systems, including the initial construction of urban freeways.

[1] In general, an incident has been defined as a spill, breakdown, accident, or any extraordinary event that restricts normal traffic flow. Chapter 6 defines the bounds of an incident more precisely.

[2] "High Technology" refers to the use of computer surveillance control systems to automatically control the freeway traffic or alert management to problems that require remedial action. Closed circuit television coverage of the freeway also qualifies as high technology.

Recent concern over environmental and energy matters, however, has lessened the relative importance of potential time savings as a basis for construction investment. It has become increasingly difficult to justify major highway improvements purely on a time-saving basis, because these time savings are offset against perceived disruption and environmental factors.

Proper freeway incident management, however, tends to reinforce rather than contradict environmental considerations. Vehicle time spent idling or moving slowly through an incident-congested area represents a total, direct waste of valuable fuel resources. Enforcement of strict engine shutoff regulations, except in tunnels, is probably impossible and may even compound the problem, since idling engines tend to become overheated and may be difficult to restart. Morever, congested flows or semistationary traffic creates severe localized pollution problems which may take a considerable time to dissipate.

Thus, improved management of freeway "incident" situations appears to be in keeping with environmental and energy considerations. At the same time, proper incident management procedures will themselves also result in a reduction in accident potential together with increases in the level of service provided (e.g., added convenience and time savings) to motorists.

Scope of this Project

In recognition of these facts, FHWA decided to develop guidelines and recommendations to assist organizations in selecting, planning, designing, and operating a responsive urban freeway incident management system. The objective of this effort was the development of these guidelines and recommendations with special emphasis placed upon developing preplanned, minimum investment systems which require neither large, extensive computer surveillance and control systems nor long periods of time for implementation. Such systems depart from the major trend of the freeway incident management operations that are high-technology efforts requiring substantial amounts of capital. The thrust of this effort lies more in the proper use of existing resources and the supplementing of these with relatively low cost but effective systems.

Current Practices

Many of these high-technology, capital intensive undertakings, often set in the context of "laboratories," are operated under federal, state and local funding. Currently, work of this nature is under way in a number of large cities such as Los Angeles, Houston and Chicago. In addition, less technological, but not necessarily less expensive, approaches to

the freeway incident management are also being carried out in a larger number of locations. For example, 16 states are currently, or have recently, operated courtesy patrols. About 19 states have call box systems, five states have them in the planning stages and seven states have inactivated or abandoned their call box systems. Finally, at least one other high-technology system has been abandoned and several others have experienced intermittent operation problems. These relatively few data points are not meant to suggest that high-technology systems are never appropriate; rather, these data serve to suggest that high technology cannot meet all the needs of the freeway incident management environment.

In contrast, several systems employing relatively low technology and low investments have been met with moderate or good success. Many of these systems involve the relatively new use of citizen band (CB) radio in the freeway incident management environment. At least 15 states, either at the city or state level, use some form of CB radio in conjunction with their freeway incident management operations. This use does not indicate that CB radio is the answer to all the problems currently experienced in freeway incident management systems, but merely indicates that there are alternatives to the use of high technology to address freeway incident management problems.

Anticipated Product of This Project

The final product of this study will address multiple target audiences. It will consist of documents and sections of documents in the incident management areas of policy, planning, implementation, training, and procedure. The possible contents of these documents are discussed below:

- the policy document would be prepared to inform the high-level administrator of the nature of the incident management problem;

- the planning manual would be directed to the person in charge of determining whether an incident management system is feasible or necessary and, if so, would provide the required background information for the selection of alternatives;

- implementation documents would contain the detailed specifications for all components of each alternative system;

- the training documents would be oriented to specific audi-

ences with special emphasis on illustrative examples drawn from actual and hypothetical situations; and

. the procedural documents would aid individuals in their performance of incident management duties both at the incident site and at the central communication or dispatching center.

In summary, each of these documents would fulfill a need that had been determined during the initial phases of this study.

Study Approach

One of the first tasks of the study was the development of a brief letter describing, and soliciting interest in, this project. The letter was sent to all state departments of transportation or highway commissions, superintendents of state highway patrols, state departments of safety, chiefs of police in cities having a population greater than 100,000 persons, selected traffic engineers, and certain professional organizations and associations. Parallel to this effort, an extensive literature search was conducted to determine what information was available that would be of use to the project and what unavailable information would be needed.

Telephone and personal interviews were held with people involved in various aspects of incident management including: those identified in the literature as being associated with major incident management systems; members of government and professional organizations and associations concerned with incident management; and those responding positively to the letter of interest. The latter set of interviews, in particular, was structured so as to obtain information on topics that were not adequately addressed in the literature and to obtain input from a representative sampling of organizational structures and geographic areas. Much of the interview effort focused on the organizational and administrative issues concerning incident management, although technical discussions were held concerning specific incident management tools whenever appropriate.

In addition to obtaining data about existing incident management systems and their operations, a significant effort was directed at obtaining actual on-site incident data. This effort involved being at the actual incident sites and noting the processes that took place. The results of this effort and of the large number of interviews with various interested organizations and agencies suggested both the strong and weak areas in most FIM environments. This led to a specification of the alternative

system structures, a tentative list of options within each structure, and the form of the project outputs. The remaining portion of this study will take this total universe of options in each candidate structure, reduce it to a meaningful number, develop detailed specifications for each option, and prepare the necessary procedural guides along the lines of the various documents already discussed.

ORGANIZATION OF THE REPORT

The organization of this report is parallel to the way a decision-maker would tend to conceptualize the FIM problem. The facts that concern the overall structuring of the candidates are presented first, followed by a discussion of the various detection options and an identification of the problems and procedures observed at the respective on-site incidents. These procedures introduce many of the administrative, organizational, and preplanning options that follow. Finally, an effort is made to determine how often many of the various detection, administrative, organizational, preplanning, and traffic control options would be applicable. This is done by examining several sources of data that suggest when the respective option's remedial action would be necessary to aid in meeting the goals of an FIM system. A brief discussion of each chapter follows.

Chapter 2 presents a general structure of the candidate freeway incident management alternatives. The candidates are structured along organizational lines. This structuring is used because the interviews with interested agencies revealed that the degree of control over the operation of the freeway exercised by the law enforcement agency governs the type of organization most likely to affect the FIM environment. The organizations that are most likely to be involved in FIM and after which the candidates are structured, are a law enforcement agency, a state department of transportation, tollway authority, a single point facility operator (e.g., a bridge or tunnel operator), a citizen group, and a consortium of involved parties characterized as an FIM team. Each of these organizations with its attendant options is discussed in somewhat general terms in this chapter.

Chapter 3 defines and presents the range of detection options that were introduced in Chapter 2 and that qualify for discussion as minimum investment freeway management systems. The detection options discussed are call boxes, both voice and pushbutton; patrols, including police patrols, service and courtesy patrols, motorcycles and others; CB radios; and electronic systems consisting of loop detectors and closed circuit television. These options are discussed with respect to cost, complexity, effectiveness, and certain other option specific issues.

Chapter 4 presents compilation of all the positive and negative aspects of the on-site procedures observed. In addition, certain options are presented as remedial actions for the traffic control problems observed. The administrative, organizational, and preplanning problems are also discussed, but options themselves are presented in Chapter 5.

Chapter 5 discusses the administrative, organization, and preplanning options that were discussed as problems in Chapter 4, and also certain other options that resulted from various interviews with the interested agencies. With few exceptions, these options require little or no capital expenditure, which should make them attractive to organizations interested in designing a minimum investment freeway incident management system.

Chapter 6 presents incident data for the evaluation of many of the freeway incident management options presented in the previous three chapters. This type of information is critical to any decision-maker who is contemplating adopting any of the options.

Finally, Chapter 7 presents a summary and conclusions that have been reached to date. The organizational and administrative issues, site activities, and several tentative recommendations are discussed.

CHAPTER 2

ORGANIZATIONAL STRUCTURE OF CANDIDATE ALTERNATIVE SURVEILLANCE AND DETECTION METHODS FOR FREEWAY INCIDENT MANAGEMENT

The purpose of this chapter is to define and present a tentative structure of the alternative candidate Freeway Incident Management (FIM) systems based upon a somewhat subjective analysis performed prior to this point in the research effort. This discussion is intended to present a general outline of each candidate system with each candidate's range of options. The alternative candidates that will appear in the final documents will not be presented; rather the total universe of options from which the candidates will be chosen will be presented. The report will also give a subjective indication of those options that seem to have the most merit. A quantitative analysis will be performed in the final documents and will include the determination of the cost-effectiveness of various options, suggesting what portion of the total universe of incidents the respective options will affect and establishing other cost-effective relationships.

PERSPECTIVE

Before attempting to structure the alternative candidate systems, PMM&Co. interviewed a number of agencies working in the FIM environment and conducted an extensive literature search. As a result of the interviews, it became evident that:

. significant consideration must be given to the organization that will operate or take the lead with respect to FIM;

. the operating environment is vitally important; and

. for nearly every option viewed, there is a spectrum of suboptions that must be acknowledged.

In general, the operating environment is governed by the local law enforcement agency charged with operational responsibility for the freeways. If the law enforcement agency views its role as one of a service organization, then this fact strongly indicates that changes or improvements to the FIM environment may have to be made by that agency. On the other hand, if the agency views its role as primarily

one of law enforcement, then other organizations such as DOTs or citizens' groups may change and improve the operating environment either by themselves or in cooperation with the law enforcement agency. Yet, in other instances (such as a tollway), the law enforcement agency is in effect an employee of the toll authority, and so improvements and changes to the FIM environment are more likely to be dictated by profit motives. Finally, from a somewhat idealistic viewpoint, there exists the possibility that changes or improvements to the FIM environment could result from a single FIM authority consisting of the law enforcement agency, DOT traffic and transportation engineers, and private, volunteer citizens.

Given this general operating scenario, PMM&Co. believes that it is much more appropriate to structure the candidate systems along organizational lines rather than to characterize the system as a hardware type (i.e., push button call box system, CB system) or as a similar type. For example, a law enforcement agency's view of a call box system, its benefits, and its associated problems is usually totally different from a DOT organization's view of the same set of circumstances. This difference in viewpoint is due primarily to differences in operational responsibility. To accommodate these different points of view, different methods of measuring performance, and, in general, different perspectives, PMM&Co. believes this material will be received better if written to specific audiences, rather than to specific types of detection hardware.

The final point to keep in mind is that each of the candidate systems has many options and that each of the options has varying levels of complexity which is somewhat conducive to project staging in concert with available resources. However, for purposes of this report, this degree of complexity will be discussed only briefly.

ALTERNATIVE SYSTEM CANDIDATES

PMM&Co. believes that the following candidate organizational structures are most likely to sponsor or organize FIM systems:

. a law enforcement agency;

. a DOT or State Highway Department;

. a tollway authority;

. a single point facility operator (bridge or tunnel operator);

- a volunteer citizen group; and

- an organization of parties interested in FIM that can best be described as an FIM team or group.

This belief is based upon the fact that, given the potential spectrum of operational environments, these actors are most likely to influence, or be responsible for, freeway operations. In addition, these actors often have resident working knowledge of the freeways and, in most instances, possess latent managerial expertise and the implementation capabilities necessary to affect the FIM environment. Finally, certain of these organizations are actors because of the fact that they are sources of Federal aid money or because they can offer large amounts of person-hours at an extremely low cost.

The framework for describing the alternative candidate systems will be a basic, general description of the system followed by a discussion of the three classes of options available. These three classes are:

- detection options;

- traffic control options; and

- administrative, organizational, and preplanning options.

Detection options are composed of equipment systems, patrols, and other methods or incident detection techniques. The total universe of detection options that PMM&Co. believes qualifies for discussion under the terms of this research effort is presented below:

- call box;

- service patrol;

- rush hour motorcycles;

- increased police patrol frequency;

- CB radio;

- loop detectors;

- toll collectors;

- stationary service patrol;

. observers in vantage points; and

. closed circuit television.

These options will be described in greater detail in Chapter 3.

Similarly, administrative, organizational, and preplanning options include activities that are policy oriented (e.g., contracts, informal agreements with the media), are aids to be developed for reference by the on-site manager (e.g., manuals, other organizations), and are general activities that are done in advance of the incident (e.g., training, alternate route planning). Those options which PMM&Co. feels qualify for discussion in this category are presented below:

- administrative options:
  - dedicated freeway unit;
  - placement of response vehicles;
  - accident investigation sites;
  - fast vehicle removal; and
  - flashing lights policy for police and service vehicles.
- organizational options:
  - police/highway department relationships;
  - relationships with other public agencies;
  - ties with transit authorities;
  - citizen group liaison;
  - wrecker contracts;
  - private sector services coordination;
  - informal agreements with the media; and
  - freeway telephone trouble number.

- preplanning options:
  - traffic operations training;
  - dispatcher's manual;
  - communications training;
  - hazardous materials manual;
  - alternate route planning; and
  - information digest.

These options are discussed in more detail in Chapter 5.

Finally, traffic control options are specific incident-site options. One such option is the use of improved equipment (e.g., electronic flashing arrows) and advanced traffic procedures (e.g., multi-route diversion) to aid the clearing of incidents at the incident site. The options that qualify for discussion are presented in Chapter 4 and are as follows:

- improved on-site equipment;
- fixed variable message sign; and
- fully equipped FIM team.

This brief overview of the options is purposely presented to obtain a clear perspective of the entire universe of options from which each of the candidate alternatives will be derived. That is, each candidate described below represents all possible combinations of the three classes of options. The final report will reduce this large universe to six alternative candidate FIM systems.

Law Enforcement Agency

A law enforcement agency that performs FIM activities is either the city, county or state police, depending upon local jurisdictional agreements. However, before this candidate can be considered as an alternative it will be necessary to determine that the law enforcement agency is service oriented with respect to FIM issues. Additionally,

each of the options presented assumes that an average basic law enforcement organizational structure exists. Clearly, some of these options may already exist as part of the existing system. For the present, the options may be viewed as the total set of choices available to any enforcement agency interested in expanding its activities with respect to servicing incidents. However, in the final product of this effort, a selected subset of the options described below will be developed into a candidate system.

The detection options to be considered for this candidate are call boxes, patrols, and various forms of CB radio. To be more specific, either push button or voice call boxes could be installed and connected to the agency's communication center. Service patrols, motorcycles, and increased frequency of the police patrol are other options. In addition, some form of CB monitoring could be undertaken.

Similarly, the administrative, organizational, and preplanning options available are establishing a dedicated freeway law enforcement patrol unit, certain informal agreements with the media, a freeway trouble telephone number, a flashing lights policy, and wrecker contracts; developing traffic operations training, an FIM oriented dispatcher's manual, and a sound highway department working relationship; and advocating laws or ordinances to have accident investigation sites and to allow for fast vehicle removal at the incident site.

Finally, the traffic control options consist of improving the on-site equipment used to control traffic near the incident and using or installing fixed variable message signs located at critical diversion points.

Given this substantial list of options it is difficult to make a subjective decision regarding which combination is best suited for any given locality without any evaluation criteria. However, if it is assumed that decreased congestion time due to incidents is high on the list of a planner's FIM evaluation criteria, then a scenario can be hypothesized.

Given this premise, the combination of a detection system utilizing the potential of the motorist's CB radio, an administrative option that assures rapid wrecker response, and an ordinance that requires drivable vehicles to leave the scene of the incident as soon as possible would greatly aid meeting the objective of reducing total time spent in congestion as a result of incidents. This is not to say that other options would not have a more dramatic effect upon congestion time. Rather, it is to illustrate what form this candidate could take in the final analysis.

DOT or State Highway Agency

From the interviews, PMM&Co. found that the general prevailing philosophy is that "the road belongs to the highway department and the cars belong to the highway patrol (law enforcement agency)." To a degree, this defines the role of the DOT as supportive rather than active and suggests that any action taken by the DOT be in close coordination with the law enforcement agency operating the freeway. Thus, before this candidate is viable, the law enforcement agency must take a somewhat passive FIM role, must actively seek DOT assistance, or be convinced DOT assistance is necessary in the FIM environment. The options that are presented below assume that the DOT takes no current FIM role.

The detection options available to the DOT are nearly the same as those available to the law enforcement agency with obvious exceptions. For example, if call boxes or CBs were used, then DOT personnel would most likely operate the system's communication center. Given this scenario, close coordination would have to be maintained with the law enforcement agency so as to avoid duplication of response dispatching. Often this type of coordination is difficult to maintain and as a result, the DOT may choose to limit its activities to providing information to the motorist and forwarding any report requiring a response to the law enforcement agency. This example, which demonstrates the problems that can arise if different agencies become involved with FIM, also serves to show that the detection options are not independent of the administrative and organizational options. Rather, the different categories of options should, and in some cases must, complement each other.

The administrative, organizational, and preplanning options are also similar to those available to the law enforcement agency, but they are oriented toward being executed by DOT personnel. The options include: establishment of wrecker contracts, hazardous materials manual, a freeway trouble number, coordination with private owners of specialized response equipment, and informational exchange ties with transit operators; development of communication training for DOT personnel involved, alternate routes and traffic operations training for DOT personnel involved with site activities; and DOT advocacy of the same ordinances and laws that were mentioned for the law enforcement agency. Note that the nature of these options is in general one of support rather than of direct action. The same is true of the traffic control options.

The same traffic control options that were available for the law enforcement agency are also available to the DOT, but their emphasis is different. For example, the DOT may be in a better financial position to actually purchase a fixed variable message sign and better on-site equipment than it would be to run the sign 24 hours a day and respond to each incident with the necessary equipment. The DOT agency is potentially in a better position to operate and maintain the sign, assess traffic conditions and recommend the specific sign message. However, the law enforcement agency may also request inputs into sign message selection. Local conditions may dictate one role or another, but the point here is that each agency is likely to see a respective option from a totally different viewpoint and to assess each option accordingly.

If these options were to be assessed from the subjective viewpoint of the DOT, with emphasis upon reducing total congestion time, then a fairly strong case can be made in favor of a combination of several of the options. For example, in detection, any role that the DOT took to reduce the unattractiveness (to the law enforcement agency) of a seemingly effective option would be most appropriate. One role that fits this situation is that of acting as central receiver for CB or call box requests for information and assistance. The DOT could handle the "unattractive" informational requests and forward the requests for assistance directly to the law enforcement agency. Administratively, handling and enforcing the wrecker contracts and other service contracts could aid the law enforcement agency in that the DOT could, by guaranteeing payment, assure the private purveyor that he would be reimbursed for his services. The DOT could then collect from the party involved in the incident. This example demonstrates this supportive role well because historically, law enforcement agencies have been reluctant or unable to guarantee payment and special equipment operators have been reluctant or slow to respond because payment was not assured. Again, this combination of options portrays what could constitute the DOT alternative candidate system.

Tollway Authority

A tollway, thruway, or turnpike is different in many respects from the previous candidates. Direct relationships exist between the level of service offered and profits. These direct relationships serve to strengthen the service outlook of the organization. The policing function is usually directly contracted by the authority and, therefore, usually plays a service-minded role. In addition, changes in operating procedure vis-a-vis the rules of the road may require only internal mandate, rather than legislative change. In general, administration of many of this candidate's options is much easier to accomplish.

The FIM options available to the tollway authority are essentially the summation of the options available to both the law enforcement agency and the DOT (with the addition of toll collection detectors) because a tollway is essentially the combination of both agencies with respect to FIM. Again, because of the uniqueness of the organization, certain options appear to be slightly different. For example, enacting a fast vehicle removal would in most cases involve legislation. On a tollway, internal mandate may be sufficient. Finally, either of the previously mentioned combinations of options also could serve to exemplify this alternative candidate.

Single Point Facility

This candidate is somewhat different from the other candidates in its smaller scope. For purposes of definition, this candidate encompasses bottleneck facilities such as bridges, tunnels, and the like that may be operated by a variety of different organizations. These facilities present special operational problems in that shoulders or emergency service lanes are usually not present and diversion alternatives are limited. Preventing blockages is therefore of utmost importance and is usually the operator's primary function. In addition, the law enforcement agency usually plays a supportive role for this goal.

Call boxes, patrols, and CBs are detection options available to this candidate also. However, due to the fact that point facilities are usually small in comparison to entire urban freeway networks, more expensive equipment, such as loop detectors and closed circuit television, is also viable. In addition, various types of observers can be used if certain conditions are met.

In contrast, the administrative, organizational, and preplanning options available are considerably fewer in number. Specifically, they include the development of traffic operations training for facility operations personnel and the establishment of an FIM oriented dispatcher's manual, hazardous materials manual, and informal agreements with the media. Finally, the single traffic control option would be the use of variable message signing at appropriate diversion points.

If the same minimization of congestion objective is used, the closed circuit television and some type of diversion necessarily rank high on the list of options that would be used to build this candidate alternative. However, as was the case before, this is merely a subjective illustrative example.

Citizen Activity

Citizen activity in the FIM environment usually stems from lack of, or perceived lack of, adequate official FIM activities. This involvement can take two forms: on-site and off-site. The former is usually met with "official" resistance because state law often prohibits other than emergency stopping on most urban freeways. The latter, if in the form of providing services that the "official" operations would rather not provide, may receive no official status, but may be unofficially welcomed. Finally, by definition, this candidate is privately funded.

Because of the fact that this candidate is privately funded, relatively few options are available. Only three detection options, service patrol, CB radio, and certain forms of observers, are viable. Similarly, no traffic options are available and administrative and organizational options are limited to establishing agreements with the media, a single freeway trouble number, transit informational exchange ties, and an information digest for use by the communications center, consisting of information most often requested by motorists. Finally, the citizen group can advocate the establishment of the same type of FIM laws and ordinances as have been previously discussed.

The relatively small number of options should not suggest that this alternative is less effective than either of the other candidates. If the CB and media agreement options were molded into a system and developed to their fullest potential, citizen activity could be a strong candidate in almost any city. In most cases, the attractive feature of any volunteer citizen group is that a great deal of manpower is available at a relatively low cost. This is particularly a significant point when considering low cost candidate alternative FIM systems.

FIM Team

The FIM team candidate is defined as the best possible freeway incident management alternative. In many respects, it resembles a tollway authority in that all response functions come under a single manager and remote management of incidents is considered to be standard operating procedure. In other respects this candidate is more idealistic than a tollway, in that all services, police, DOT, citizen, and other, are integrated into one multifunctional service unit. All management and operation functions are in the charge of professionals whose primary goal is to keep the freeway traffic moving. The preplanning is stronger, more detailed, and includes documented operating procedures in its execution. The outstanding feature of this candidate

is that major incidents receive the attention of a multidisciplinary FIM response team. This candidate defines the most elaborate of the minimum investment FIM systems.

Because this candidate is the most elaborate, it embraces all of the various options previously discussed under the respective candidates. The options that could make up this candidate could be similar to the examples previously presented. However, due to the fact that all FIM functions fall under one central authority, all aspects of the candidate would be maximized. For example, training is advanced, support materials are comprehensive, communication ties are well documented, and other services are efficient and professional. In essence, this is the best candidate, with a cost likely to reflect this fact.

In summary, because this candidate is likely to be expensive, it may be the least likely to be chosen. It is not an unrealistic candidate, but given real world budgeting limitations, it is doubtful any city or state could afford a full-fledged FIM system in any given fiscal year. Therefore this candidate may have to be viewed as the goal any system should try to achieve over a period of time. If this candidate were viewed as such, then respective portions of the system could be added, based upon cost effectiveness, as budgeting and other considerations allowed. In this light this candidate becomes an alternative and certainly merits consideration by FIM planners.

SUMMARY

This chapter has defined and presented a tentative structure of the alternative FIM systems. The candidates are based upon subjective analysis performed as of this point in the research effort. As such, the candidates were presented in terms of the total universe of options available to low technology, minimum investment systems. Illustrative examples of what the final candidates may be were given in terms of grouping options that appear to be best suited to meeting research objectives. The options themselves were not discussed in any great depth. Rather, they were presented only briefly for a clear overview. The chapters that follow discuss many of the options in greater detail.

CHAPTER 3
DETECTION OPTIONS

The detection of freeway incidents is the vital first step in the incident management process. Detection of a freeway incident includes identifying and reporting that incident to someone who will respond. The means of detection can range from little more than structured observations to sophisticated hardware and software systems. Although the latter are beyond the scope of this project for the most part, some limited applications of advanced technology have been considered as potentially appropriate in certain instances.

Approximately 10 different types of appropriate incident detection options are presented below. Certain of these systems may be considered "passive" in that the system detects the incident, while others may be considered "active," requiring detection inputs from the involved motorists or cooperative passersby. The detection options discussed are: call boxes, both voice and push button; patrols, including police patrols, service patrols, motorcycles, and others; CB radios; and electronic systems consisting of loop detectors and closed circuit television.

Each of these options will be discussed in a parallel format. First the option will be defined and its range of complexity explored. Second, characteristics of the option that would be common to any operating organizational structure contemplating use of the system will be presented. Third, issues specific only to individual agencies will be discussed. Finally, an assessment of the detection option will be made based upon the literature, interviews conducted with responsible agencies, and PMM&Co.'s synthesis of both.

OPTIONS

Each option will be discussed following the above format.

Call Boxes

Discrete roadside communication terminals, commonly termed call boxes, are one of the most widespread classes of surveillance and detection systems currently employed on limited access freeways. At least 24 states are known to have call box systems of one type or another

(106, 168, 157, 180).[1] All systems have terminals located just off the roadway. Terminals are generally spaced from one-fourth to one-third of a mile (.4 to .53 kilometers), although both larger and smaller spacing does exist. The preferred position seems to be two terminals at each field location, one for each direction of travel (185). Terminals are also placed in the median strip, either in a central location or on each inside roadway shoulder (84). The method of interfacing between a terminal and the communications center depends upon the type of system.

The types of systems investigated included roadside telephone (185, 186, 217), roadside radio phone (54), roadside push-button wire call box (180), and roadside push-button radio call box (151, 54, 83, 84). All the systems, although possessing different physical characteristics, perform generally the same function and are linked to the communication center console by wire or radio. Voice systems consist of a closed box with a telephone handset inside. Push-button boxes, as the name implies, are a closed box that offers the motorist a choice of buttons to push based upon his particular need.

Coded or push-button communication systems have at the communication center a simple console with audio and visual alarms and signals to identify the type of response desired and the location of the caller. Newer push-button call box systems have visual and/or audio signals in the call box that confirm the reception of the coded message by the control center. Voice call box systems also have communication center control consoles with audio and visual alarms. In addition, voice communication center equipment is necessary and the system may have signals for indicating the location of the request.

In the field, information signs concerning the existance of the system are located usually at the beginning and at points throughout the section under surveillance. Specific signs usually identify the terminals and are placed on the terminal mounting poles.

Having recognized that the system exists, a motorist or a cooperative passerby must make his way to the site of the roadside terminal to use the system. In the telephone and radio phone systems investigated, once the aid request is received at the communication center,

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[1]The numbers in parentheses( ) in the text are reference numbers.

[2]Cooperative passersby also report incidents. Reference 215 indicated that trucks made up only 10 percent of the traffic volume, but made 21 percent of the calls.

the proper response vehicle is dispatched immediately. Push-button systems may or may not immediately dispatch the type of aid requested, depending upon the operating policy. In the majority of the cases, police units are sent to the scene to confirm the motorist's needs prior to dispatching the needed response vehicle. Finally, charges are usually made for services rendered, especially if private vehicles are dispatched.

Issues Common to all Organizations

Issues common to all organizations considering call box systems are cost, simplicity, reliability, safety, and effectiveness. This following information is based upon the best data available. However, the data is in many cases adequate only for presenting ranges of values. This is especially true for the cost issue data.

Cost is important to any organization considering call boxes. Indeed, PMM&Co. seriously question whether call boxes qualify for discussion under a research contract concerned with "minimum investment systems." Sources indicate that the capital costs per unit range, on the average, from $1,000 to $2,000 (106). Annual maintenance and operational costs ranged from about $200 to $800 per unit per year. At spacings of two or three locations (4 to 6 units) per mile (1.6 kilometers) any call box system is an expensive proposition. However, cost is not the only major concern.

Simplicity is typically another operational concern, as is the traveling public's awareness of the system. One researcher has suggested that it is impossible to reach 100 percent public awareness of the call boxes; rather it is reasonable to assume that if, over a period of time, about 70 percent of the regular highway users are aware of the system, then a negative impact upon the system effectiveness can be avoided (106)[3]. Once highway users know that the system exists, typical estimated use is approximately one call per 7 to 45,000,000 vehicle-miles (11.2 to 72,000,000 vehicle-kilometers). A significant study fact is that the low use was generally in urban areas where there were readily available alternatives. Finally, no one disputes the fact that in concept call box systems seem simple to use. Therefore there must be other causes for this relatively low use.

[3]The same researcher found that a large body of literature indicates that about one disablement per 23,000 vehicle miles (36,800 kilometers) has been determined as a reasonable estimate of stoppages. The range was from one stop per 10,000 miles (16,000 vehicle-kilometers) to one stop per 50,000 vehicle miles (80,000 vehicle-kilometers).

System reliability may account for a portion of this low use. For example, one newspaper journalist found that 46 percent of 59 call boxes were out of order during a random test day (184). Another system test of 165 units found that only 75.3% were operational (106). Others have reported that busy signals, confirmed calls not responded to, high cost of response service, and easy access to alternate forms of assistance, particularly in urban areas, are reasons for the lack of system use (173).

User perception of system safety may be another reason that the system is not used. It has been reported that 43 percent of all pedestrians killed in a particular study area of California freeways were pedestrians who had gotten out of their automobiles (107). Also, parents would be reluctant to leave youngsters unattended to walk to a call box. Finally, it may be unsafe to leave the shelter of a stalled car in times of extreme cold or poor visibility.

Cost, simplicity, reliability, and poor safety are certainly important system concerns. However, effectiveness of the system is by far the most important issue.

The effectiveness of the system centers on its use. Twenty percent of the disabled motorists used a voice system (106), which was the greatest use of that system in any urban area. In another urban situation about 22 percent of the motorists used the push-button system (106). The data are limited for this subject, but judging from existing data, there does not appear to be a great difference in the use of voice versus push-button systems. In contrast, the voice system versus the push button system is an issue with respect to the agencies operating the systems.

Intuitively, the voice system is very appealing. Voice communication provides the motorist with a sense of reassurance and greater flexibility in specifying problems, and directing specific responses. However, communication centers that are already overburdened, find that requests for weather conditions, directions, and long conversations are detriments of voice systems and points in favor of having push button systems[4]. There have also been cases where push button systems have been chosen over voice systems because the former costs less. In addition, at least one source reports that experienced control center operators of push button systems can develop an expertise that allows them to differentiate between serious accidents or pranksters by correlating the number of

[4]An attitude that suggests that lost or confused motorists are not a problem is at best short sighted and certainly not in keeping with the intent of a motorist aid system.

calls, location, and buttons being pushed. Another factor which may determine a preference for the voice system is a low incidence rate of gone-on-arrivals, which comprise 8 percent of the calls on push button systems (106). However, no data is available to support this hypothesis.

A final problem that any public organization might face is political pressure against the call boxes. At least in one instance commercial radio stations successfully lobbied against the call box system on the grounds that they were providing the motorist aid service with their broadcasts from aircraft (253). This pressure was eventually overcome, but not until certain modifications to the system were made.

Organizational Specific Issues

Specific organizational issues center around three agencies, the law enforcement agency, the DOT, and the single point facility. The availability of 90/10 federal funds has historically made the state DOT the call box purchasing agent. This came about because the funds have been available through DOT channels. However, in only a few instances does the DOT actually operate the system after installation and testing is complete. Rather, another agency, usually some type of law enforcement agency, is given operational responsibility. This can raise serious problems if the purchasing and operating agencies efforts are not coordinated through out all phases of the project. In fact, there is at least one case where an entire call box system has been abandoned after 22 months of operation because of conflict between the purchasing and operating agency (106).

In instances where the entire system was purchased and operated by a single agency, such as a toll bridge, there is no conflict. Preliminary indications are that single point facilities such as bridges or tunnels which are equipped with call boxes are the only facilities that are within the scope of this research effort. The reason for this is the cost of congestion is extremely high on these facilities and the number of call boxes relatively low thus making the call box system somewhat more attractive.

Assessment

In view of the somewhat negative aspect of most of the above issues, the future of call boxes is unclear. An especially negative aspect is the low percentage of incidents that use call boxes. Another factor that will come into play later is the fact that other systems promise to be more effective. In fact if the current CB usage continues and if the CB detection potential is realized (see CB radio section), then there is a possibility that call boxes may become obsolete or change their form entirely so that portions of the call box, such as the transmitters, act as remote

transmitters for the relatively short ranged CB radio. In summary, any agency seriously considering call box systems in the future will have to be cognizant of the other alternatives available.

Patrol

Incident detection by patrol is defined as the use of a vehicle or fleet of vehicles to detect incidents. As discussed below, a patrol spectrum has several dimensions including temporal coverage, geographic coverage, and the capability to perform multiple FIM functions. However, this discussion will be limited to only those aspects of the patrol that are pertinent to incident detection.

Spectrum

The features used to characterize the patrol spectrum are the percentage of a day that the detection capability is available, the area covered by a patrol system, and the vehicle or vehicles used in the act of detection. The range of patrol types is from aircraft, that provide complete areawide coverage but that are usually available only during the rush hour, to police traffic patrols and service vehicles that provide 24-hour coverage only on the freeways. There are options that vary considerably in several respects. For example, police patrols may have law enforcement as their primary function and traffic control as a secondary function and thus are incident dectectors on a part-time basis. Service patrols may patrol only areas of the freeway that experience high incident rates or only on weekends and holidays. These patrols perform FIM duties other than detection and are therefore part-time detectors. No attempt will be made to characterize every type of patrol that PMM&Co. observed; rather all the various suboptions will be first categorized as either a police patrol, service patrol, or aircraft patrol and then will be discussed in terms of their area and temporal coverage as well as their other distinguishing operational features.

Police Patrol. A police patrol detector can take many forms. The most common form is that of state patrolman, or city policeman, whose function is 24-hour area-wide law enforcement. Incident detection is usually done as a secondary function. There are also traffic police units dedicated to keeping the traffic moving. Detection is their primary function and is usually tied closely with prevention. Dedicated freeway traffic units often concentrate their efforts at high incident locations and during periods of the day when incidents are most likely to occur. Thus, their detection is more productive. (See Chapter 5 for a more detailed discussion of a Dedicated Freeway Unit.)

In addition to differing from regular police patrol in detection emphasis and productivity, the traffic police patrols also differ with respect to vehicles used. The regular patrol usually uses an ordinary police cruiser with its attendant equipment. The traffic patrols may use the same cruiser but add certain features (see Chapter 5), or they may use motorcycles or specially equipped station wagons. In general the traffic patrol vehicles have been found to be modified to fit the circumstances, whereas, the enforcement patrols employ whatever vehicles the budget allows. It is necessary to recognize that any four-wheeled vehicle will provide a detection capability equal to any similar vehicle. Only the motorcycle offers a greater ability to get through stalled traffic to detect the cause of the incident.

Service Patrol. Service or courtesy patrols on the freeway are usually specially marked pickup trucks, tow vehicles, or station wagons. As the name implies their primary function is to service incidents. In this respect, detection is also a primary function, but it is not a full-time function because the time spent attending to a specific incident is time not spent detecting other incidents.

The vehicle type affects its ability to detect incidents. For example, a well equipped vehicle will be able to service more incidents, whereas a less well equipped vehicle will be able to service fewer incidents. However, the latter will be able to spend more time detecting because less time will be spent in servicing incidents. Vehicle types encountered during the course of site visits ranged from specially equipped medium-duty tow trucks to ordinary 3/4 ton pickup trucks.

Detection time coverage also may be limited only to rush hours or specific high incident time periods. In addition the service patrols' geographic coverage may vary from total area coverage to partial area coverage to single facility coverage. Another aspect of coverage is the frequency of patrol. Publicly financed operations tend to have 24-hour, 7-day patrol coverage, whereas operations financed by private citizens, auto clubs, and CB clubs (see the CB Radio section) tend to give rush hour, weekend or some other part-time, infrequent service.

Aircraft. Both fixed wing aircraft and helicopters are used for incident detection. Private operations, such as a radio station patrol, function solely to detect and report incidents to the motoring public. Public agency aircraft, such as police helicopters, often are multifunctional and some become airborne only after major incidents have occurred and so are at best part-time detectors.

In contrast, coverage by private operations tends to be on a full-time, rush hour basis and coincides with the coverage provided by the radio station. This has two effects upon detection. First, detection is not limited

to the freeways but also takes in all surface streets and thus lessens the total freeway detection capability. Second, due to the large area covered, it is difficult to maintain a high frequency patrol. Therefore, the coverage is less comprehensive than it could be ideally.

Issues Common to All Organizations

Detection issues common to any organization undertaking an FIM operation are: cost, number of hours of operation per day, effectiveness, safety, and weather conditions that can render some of the options useless.

Cost is the traditional issue that has been most discussed when considering any type of patrol. Appendix B shows the total cost of the various patrols in 1976 dollars. However, if it were possible to break out only those costs associated with the detection of incidents, it would provide more meaningful information for comparing the patrol detection with other detection options. The literature and individuals contacted by PMM&Co. during the course of the study failed to provide any data reflecting the cost of patrol detection alone.

In an effort to isolate those costs associated only with detection, a typical patrolman's day was used to determine the percentage of the day dedicated to incident detection. This factor was then applied to the police patrol costs previously mentioned. A similar exercise has been performed for the service and courtesy patrols and is shown in Table 1.

A possible reaction to these costs is that detection is expensive. In fact the PMM&Co. site visits found that cost has been cited as the reason for discontinuing a motorcycle patrol, reducing scope, and discontinuing service, courtesy, and aircraft patrols and dismantling police traffic units. Only one exception to this trend was found: a particular traffic unit paid its own way with citations. It is not clear if cost is the only determinent, but the trend seems to indicate that patrols are being deemphasized and cost is being given as the reason.

Another issue closely related to cost, but which only pertains to service patrols, is the number of hours a day that detection is carried out by a particular patrol. Intuitively, a rush hour service patrol would seem to be less expensive than an eight hour patrol. However, this is not necessarily the case for a variety of reasons. From the limited number of contacts made, PMM&Co. learned that to obtain reasonably qualified persons, eight hours of pay per day is required. Premiums have to be paid for shift splitting if that is considered. Finally, if such hour patrolling is assigned

TABLE 1

DETECTION COSTS FOR PATROL VEHICLES
(In 1976 Dollars)

PATROL TYPE	HOURS OF OPERATION	LABOR COST PER PERSON PER YEAR	VEHICLE COSTS PER SHIFT PER YEAR
Police Enforcement or Traffic Cruiser[1]	8	$6,331-8,863	$2,070-2,849
Service or Courtesy Patrol[2]			
a. for detection vehicle-pickup truck	8	$8,120-14,616	$2,517-2,923
b. for detection vehicle-tow truck	8	$8,120-14,616	$5,066-16,890
c. for detection vehicle-motor cycle	8	$8,120-11,368	$ 730-1,868
Aircraft[3]			
a. helicopter		Total	$112,320
b. fixed wing		Total	$ 26,000

[1]From reference 171, a patrolman's time is spent as follows: 52.5 percent patrolling, 2.44 percent commuting to the beat, 16.75 percent doing administration, and the remaining time doing nondetection functions. This discussion assumes one-half of the administrative burden is borne by detection. Thus, detection costs are 63.31 percent of the total patrol costs indicated in Appendix B.

[2]Reference 171 shows that 54.94 percent of the officer's time is spent in detecting and travelling to his beat. Motorist services account for 2.96 percent of his time and accident investigation accounts for 3.8 percent. Thus, for every eight minutes spent detecting or patrolling, about one minute is spent on motorist aid related duties. It can be assumed that since the service patrol is in the same environment, the same ratio of detection to motorist aid may hold true. Assuming an 8.3 percent overhead burden and applying the 8:1 ratio results in 11.5 percent of his time for motorist aid and 81.2 percent for detection. Thus, service patrol detection costs are taken to be 81.2 percent of the costs indicated in Appendix B.

[3]Aircraft costs are not changed due to the fact that detection is the primary function performed by the aircraft. Other tasks are assumed to be inconsequential.

to employees that normally do other tasks during the regular work day, then overtime must be paid. One potential solution to the problem would be a combination of four hours rush hour service patrol work with four hours of some other type of work. However, most rush hours are not amenable to this solution. Some type of shift splitting surcharge would probably be incurred.

Cost is a central issue to any discussion of this type. However, it is only meaningful to a decisionmaker when it is expressed in terms of what any level of expenditure will do or how effective it is relative to similar expenditures for alternatives that would perform the same function. Data reporting on this aspect of FIM is exceedingly hard to obtain. Only one source (106) reported on this. Prior to implementing a service patrol, 20 percent of the motorists used callboxes, 45 percent of freeway incidents were detected by police patrol, and commercial tow operators accounted for 23 percent of the assists. After the institution of a service patrol, the service patrol was able to detect and respond to over 70 percent of the disabled vehicles. The report failed to mention the call box role and the police patrol activities during this latter time period. In addition, it would be useful to ask if those incidents detected were the total number of incidents or if they were the number of incidents that lasted longer than some nonspecified time period. Presumably, the latter is the case. If this were the case, then 70 percent is a major improvement over the percentage of response by other detection options used.

Perhaps of equal importance with cost is safety. It has already been noted that pedestrians on freeways have an extremely high mortality rate. A patrol system is inherently safer in this aspect due to the fact that it is passive with respect to the motorist. That is, the motorist waits in the vehicle until detected, rather than leaving his vehicle to summon aid.

On the other hand, the idea of waiting in the vehicle to be detected can be met with mixed emotions during inclement weather when certain types of patrols are operating. For example, during snowstorms and severe weather, both motorcycles and aircraft are rendered completely useless. That is not to say that the freeway authority would leave the freeway completely unpatrolled during bad weather; rather it is meant to suggest that the wait may be a great deal longer than one would like due to the fact that the total system's detection capability may be greatly reduced.

Organizational Specific Issues

Probably the single most significant, specific organizational issue is the question of a police patrol's primary function. For example, in cases

where the policeman is a generalist and in charge of a sector of the city through which a section of freeway runs, PMM&Co. found that detection, to the extent that it occurs, is met largely with lack of enthusiasm. Traffic, for the most part, is of secondary concern. In contrast, 100 percent of the traffic specialist's time is assigned to the freeway and he is sensitive to all aspects of traffic management. The specialist usually is prevention minded and, as such, has studied incident trends and is likely to detect a greater number of incidents with the same effort because he patrols most heavily those areas where incidents are most likely to occur. Over time, traffic becomes sensitized to this effort and it was found that at least one department affected the driving habits of motorists due to the emphasis upon detection and prevention. In summary, the issue of specialist versus generalist is central to the assessment of the police patrol's usefulness as a detector (see Chapter 5).

Assessment

As has already been indicated, worth of a police patrol as a detector is determined by whether or not the patrol officer is traffic oriented. PMM&Co. feels that if additional detection capability is sought and a generalist police patrol is the only type of police patrol available, then other types of patrols for the additional detection capability would be necessary.

Service patrols probably would serve the need best in the absence of police traffic patrols. PMM&Co. feels that total areawide application of service or courtesy patrols is not the answer. Albeit a seemingly cost effective detector, it is doubtful that very many cities could really afford such an investment on a continuing basis. Rather, service patrols seem to be best suited to patrolling and detecting in high incident areas, where detection productivity will be high and where response and site activities performed by the patrol will be vital to the entire freeway network.

Motorcycles are probably better suited for detection in high incident areas or on bottleneck facilities. However, definitive demonstrations would be necessary to prove their worth in terms of the total detection, response, and site clearing scenario. A motorcycle may be able to detect an incident and reach the site quicker, but a fully equipped patrol car or service vehicle, which may take longer to reach the site, may clear the congestion much sooner upon arrival. In sum, the motorcycle in good weather appears to be the better single point detector. However, a decision should be made before the purchase of this or any detector about its worth to the total FIM environment.

Giving consideration to the total FIM environment is particularly important in PMM&Co.'s assessment of aircraft, particularly helicopters. At their best, aircraft are adequate detectors only in good weather.

Expense and their ability to detect but not respond, make them questionable alternative options. PMM&Co. feels that as far as FIM is concerned, they are useful supplements to existing detectors. That is, if someone other than the FIM organization, such as a radio station, has an aircraft at its disposal and offers to help detect incidents, then the offer should probably be accepted. Subjectively, it seems that purchasing an an aircraft solely for detection purposes is not worthwhile. However, a cost-effectiveness analysis will be done later in this study to provide a quantitative basis for making such a determination.

In summary PMM&Co. feels that the best overall patrol detector may be the traffic police patrol. In its absence, and for limited applications, the courtesy or service patrol is probably a good second choice. In terms of detection alone on bottleneck facilities, the motorcycle has a lot to offer, weather permitting. Finally aircraft are probably useful as a secondary detector, but not at the cost of the agency performing the detection.

Citizen Band (CB) Radio

Having CB-equipped motorists detect and report incidents via their CB radio is central to this detection system. As will be seen below, the organization of the detection effort can take many forms and the area covered can vary greatly, but always central to the detection and reporting functions is the CB radio. As is the case with the patrol, CB detector systems perform a variety of other services. However, this discussion will center upon the use of CBs as detectors.

Spectrum

The parameters used to characterize the spectrum of CB systems are organizational types and area of coverage[5]. Organizationally, either a law enforcement agency or a citizen group is the leading organizer of the detection effort. The area of coverage is of somewhat less importance and is dependent to some extent upon the organization's jurisdictional coverage and/or the range of the CB. The most meaningful way to discuss the spectrum and also address each of the parameters is through examples. Five examples have been chosen to represent a cross section of systems: The Missouri State Highway Patrol (MSHP), a city police department that uses CBs located in fire stations, the Ohio REACT program, the Michigan Emergency Patrol (MEP) and a citizen's courtesy patrol.

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[5] Time of operation, although usually a parameter, is not important here because most of the systems studied operated 18 to 24 hours a day.

Police CB Systems. Although, the MSHP is not the only state police agency that equips all their vehicles with CBs, they were one of the first and as such have appeared in the literature (148), have taken the initiative to collect some data, and were interviewed by PMM&Co.

The MSHP program has concentrated upon equipping all vehicles and troop posts with mobile and base station CB radios. The thrust of the program is indicated by the fact that the radios are capable of monitoring the National CB emergency channel, Channel 9, and one other selectable channel. Thus they select or listen to the local truckers' channel for informational purposes until there is an emergency on Channel 9, which automatically overrides the selected channel. In addition to the CB radio, the cruiser is equipped with the normal police radio equipment.

As the name implies, the MSHP covers an entire state and, as such, is not totally applicable to this research effort, which is concerned with urban freeways. However, a portion of the coverage of MSHP is in urban areas and some of the general features of the concept appear to be universally applicable.

The second police CB system is totally applicable to this study. The motivating force for this CB incident detection system in a city of 280,000 persons is the police department. The outstanding feature that makes complete city coverage possible is the tremendous cooperation between the police and fire departments. The police have arranged to have CB base stations installed in certain fire stations. The fire stations were chosen in such a manner so as to give total citywide coverage with a minimum of overlap. Hotlines were also installed in the respective fire stations so that direct police communication could be maintained. As a result, the firemen respond to all calls for information on a 24-hour basis and forward all incidents to the police department (including nontraffic incidents). This arrangement has additional benefits that are secondary to FIM and will be discussed in later sections.

Citizen CB Systems. The Ohio REACT Program has been reported upon a great deal in the literature (29, 215) and no attempt will be made to duplicate that effort. It is sufficient to say that the program organized citizens in an effort to provide statewide coverage of Channel 9. This effort was not fully attained in the rural areas, which are of little importance to this study. What is of importance is the fact that total coverage was not obtained because interest or motivation on the part of volunteer citizens was not generated. This latter fact may have universal application and certainly merits consideration.

The volunteer and unstructuredness aspect of the Ohio REACT program makes the program difficult to evaluate due to the fact that data collection was sometimes haphazard and incomplete. However, the system did collect FIM detection data as well as many other types of emergency data. It is only partially applicable to this study due to the rural nature of the entire program.

In contrast, MEP is totally urban in nature. Its name is a misnomer in that patrolling is not done, but rather the system consists of a base station, located in one of Detroit's taller buildings, that monitors Channel 9. This system is also reported in the literature a great deal and will not be repeated here (148, 149). The system coverage is as comprehensive as possible with the current equipment and the information dissemination is supplemented with direct ties to several radio stations. As with the previous system, MEP also has a problem obtaining enough trained operators on its membership roles. Part of this problem may stem from the fact that a high level of training and commitment are required of base operators as is reflected in the large amounts of data that they have collected.

The data reveals that the single largest category is requests for information by the motoring public. Calls to MEP for general information, some of which are incident related, make up the second largest category. Calls reporting stalled vehicles make up the third largest, and calls pertaining to accidents make up the final category. This breakdown indicates that even in an urban situation, detection is secondary to information requests. Finally, it should also be noted that this system covered all urban streets, not just the urban freeways.

In contrast, the last citizen CB system to be discussed is operated solely on the freeways of a large metropolitan area. The system consists of several CB radio equipped vehicles patrolling about 20 miles of urban freeway, which is about 20 percent of the total freeway mileage in that area. It operates only on the weekends and over holiday periods. Thus the system detection is limited in both time and coverage.

These limitations seemed to have solved the manning shortages that the other citizens systems experienced because volunteers are not a problem. However, the system does have other problems, at least from a research point of view. System records and data of the number and type of incidents detected in certain time periods are almost nonexistent. Another problem which has been previously touched upon is the fact that the patrol is not only a detector and, as such, determining what percent of the total time is spent detecting is difficult. At the time PMM&Co. visited this system it was about four months old and its newness accounted for the fact that no data were being collected. In addition, as the novelty of the system wears off, recruiting volunteers could also become a problem.

In summarizing the five systems, it should be noted that there are literally millions of CBs in the possession of motoring citizens. This increase has been relatively recent. In early 1974 the Federal Communications Commission was processing about 15,000 applications for license per month. In January 1976, applications increased to 515,355. Of course, not all of these radios are in vehicles and it has been suggested to PMM&Co. during the course of the interviews that not everyone bothers to obtain a license. (In fact, it has been suggested that as few as one in three CBs is licensed.) The Electronics Industry Association has said that as of the middle of 1975 about one in seven autos is equipped with a CB radio (147). During the course of the PMM&Co. field visits, it was learned that a city with the population of about 280,000 persons had a CB radio owning population of over 63,000. This number is a count of citizens who chose to join a particular program. Police officials estimate that the actual CB population is about 75,000 or about one radio for every four persons, because many families have more than one radio and simply registered as one unit in the program and others may have chosen not to join the program. This suggests it may be possible that one vehicle in four is equipped with a radio in this particular city. In terms of detection potential, this means that every fourth auto may have the potential of reporting an incident. This type of capability approaches a continuous detector system during the rush hour and as such is worthy of attention when considering low cost FIM systems.

Issues Common to All Organizations

The issues common to all organizations with respect to the CB detection system are effectiveness, cost, safety, and operational limitations.

As has been suggested in the previous section, the potential effectiveness of the CB system is great. If the CB population data that PMM&Co. obtained are at all representative, then future FIM planners will have to reckon with the problem of determining the effectiveness of CBs as detectors. To date, no study has been performed that attempts to relate the effectiveness of CB with respect to incident detection. Rather one would have to rely upon work done in other areas and attempt to extrapolate the results.

For example, if it is assumed that each CB equipped vehicle is nothing more than a patrol without the capability to render any type of aid, then it is possible to suggest the level of detection effectiveness. At least one source has suggested that if patrol frequency is two minutes (not an unreasonable assumption if you consider a multilane freeway and the fact

that one in four vehicles may have a CB radio), then the probability of detecting the incident within five minutes is .9 (156). Similar statistics are available for different patrol frequencies in the same source. This is a very good rate of detection but, it is not without potential problems.

One of the problems that plays a very significant role is channel overloading. In addition, diathermy equipment, which is used in hospitals, and atmospheric skip tend to cause AM interference. The FCC may solve part of the problem by expanding the number of channels. Also in some instances CB users tend to police themselves and only transmit when their input would aid the emergency.[6]

A related problem is that of false reports. PMM&Co. has found during the course of the field visits that this is largely a perspective problem. That is if an agency's policy is not to have CBs, then one of the reasons for not having them is that there are too many false reports. However, if an agency has CB, the false reports are not a problem. Advocacy may be the issue, but the majority of the opinions seem to indicate that false reports by telephone are more frequent. Whatever the true statistics are, the FCC has a proposal (in the form of Docket 20351) that would attempt to solve this problem and the problem of CB radio theft which has also become very prevalent.

Docket 20351 has proposed an Automatic Transmitter Identification System that would automatically broadcast the call sign of the CB unit whenever the microphone was activated. Thus the identity of the false reporter would be known for future prosecution. Similarily, a thief would have to deactivate the mechanism before resale, (because the call sign would be registered with the FCC), which would serve to alert the unsuspecting buyer. However, it should be noted that at this time this proposal is in only the very preliminary stages of becoming actual law.

One of the factors contributing to the theft problem is the cost of the CB units, which can range from less than $50 to more than $750 per unit (175). This can be a expensive accessory to one's auto. However, many people, as previously indicated, are apparently willing to pay the price. The paradox of the cost issue is that to the FIM operating agency the cost is next to nothing due to the fact that the local citizens are already equipped. The cost of a base station with antenna, a certain amount of backup capability and accessories, such as hot lines to police agencies and radio stations, can be obtained for $1,500 to $2,500 per base station in most cases.

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[6]One system used Channel 23 as the designated emergency channel to minimize side channel interference and to obtain nearly 100 percent cooperation from the public.

Depending upon geography, size of the area to be covered, and certain other factors, the cost for total coverage could be expensive. However, if, for example, a city with a population of about 280,000 were to be given total coverage within its city limits, three or four base stations would suffice, which would be relatively inexpensive.

The final issue common to all organizations is safety. Obviously the disabled motorist with a CB radio does not have to leave his auto to summon help. The additional intangible benefits of the voice call box system are also enjoyed by the CB. Finally, for the nonuser of the CB the wait for detection is probably shorter than with a true patrol system because there is a greater number of CB radio equipped cars on the roads.

Organizational Specific Issues

An issue that has been universal to each police agency interviewed that did not possess CB units is illegal or improper CB usage by the average trooper. In addition, they are concerned that vigilantism may become a problem and about any additional work load that may be coincident with CB monitorship. Finally, enforcement orientated police departments tend to feel that requests for information are not part of their primary mission objective.

These problems have been dealt with in a variety of ways by those police organizations that use CBs. The potential for illegal or improper use has been met with special memoranda (194) that specifically outline what is and is not proper use. The police agency combats potential vigilantism with public information and slogans such as "We want vigilance, not vigilantes." The additional work load problem and the information problem have been dealt with, in at least one case, through cooperative agreement with a sister agency. In addition, certain police agencies, who have interpreted their role as one of service to the public, rather than only strict enforcement of the law, do respond to information requests as time and other duties permit.

A problem that DOTs foresee takes on a much different nature. Since most DOTs do not maintain a 24-hour capability in all maintenance or operations facilities, several agency personnel feel that it would be worth the additional cost incurred to maintain a 24-hour areawide operation or that less than 24-hours monitoring would be done. Others, as has been previously mentioned, feel that this sort of activity is not a DOT responsibility, but rather a police function. However, this latter opinion was expressed by the minority of DOT agencies contacted.

Assessment

In terms of meeting research objectives, such as noncomputer surveillance alternatives and minimum investment, the CB system appears to be the best detector from the stand points of cost and coverage. CB use does have its draw backs and is affected by weather, potential false reports, and various types of electronic interference. PMM&Co. feels that to capture this tremendous latent potential will require clever organizational effort on the part of the agency interested in FIM. Finally, the agency will have to realize that in return for obtaining relatively low cost detection information from the CB using public will be the provision of information about roadway conditions, weather conditions, directions, and other requests.

Paradoxically, the provision of this type of information could be met with opposition from private enterprise if not handled properly. As mentioned above, call box systems met with opposition from commercial radio stations because of the unfair competition with respect to the provision of motorist information. One possible solution is to provide certain freeway condition information to the radio stations like the MEP operation does. In summary, the fact that must be emphasizid and recognized by an FIM planner about the CB detection option, is that although it may be relatively inexpensive to finance, it may require a great deal of organizational effort to implement.

Electronic Detectors

Electronic detectors are devices that indicate when a vehicle moves by or through a selected point or area. As will be seen, these devices are relatively expensive and as such only point facilities, such as bridges or tunnels, will be considered for potential application of this detection hardware. Covering entire networks or complete freeway systems with this type of detection is beyond the range of a minimum investment system.

Spectrum

Two detectors will be discussed in this spectrum: loop detectors and closed circuit television. Initially, the only common aspect between the systems seems to be that both require electrical current to operate and that both are the ultimate in remote detection. To a large extent the fact that the systems are so different is the primary reason for discussing both of them together because the strength of one tends to complement the weakness of the other.

For example, loop detection is not labor intensive, while CCTV requires someone to monitor the visual output of the system. Loop detection can sound an alarm when an incident has occurred, but the system operator is at a loss about how to respond. CCTV requires that the observer be attentive or the incident may be missed (which has been an operational problem in the past) but, once an incident is detected, a response can sometimes be determined. Finally, loop detection systems have primarily been used in conjunction with for ramp metering purposes. Thus any transfer of operating knowledge must be extrapolated, where as CCTV has been used expressly for freeway incident management detection.

Operationally, the latter is somewhat straightforward because it produces a visual picture as output and requires ljttle elaboration. However, to understand the former will require an explanation on a somewhat generalized level.

An inductive loop consists of several turns of wire in a square loop embedded in the roadway. The loop is tied by either land lines or radio transmission to some type of computer. The computer queries the detector and uses the response in conjunction with an algorithm to determine traffic conditions. Depending upon system sophistication, the results may appear as direct hard copy or as different colored lights on a network board.

The literature reports (12, 10) at least twenty different ways to electronically observe or detect a vehiclar flow with nonvisual output equipment. There is a large number of computers on the market today. Recent literature (152, 51, 187) indicates several types of algorithms and the desired output is as varied as the user's requirements. In summary, thi spectrum, consisting of all the combinations of all the different subelements of the system, represents quite a large number of combinations. However, the scope of the discussion will be limited to the loop detector system, with a computer, an algorithm, and a network board as the output device.

In contrast to the multitude of different types of "blind" detectors, there is essentially one type of optical electronic detector--closed circut television. The spectrum of CCTV can vary considerably with respect to optional equipment for the camera such as the ability to operate in low light conditions, the capability to pan over large areas, etc. However, the spectrum consists of camera mounted on a structure of some type, a transmission medium, and a monitor.

Organizational Specific Issues

DOTs, point facility operators, and tollway operators have been found responsible for all of the systems employing these two means of detection. As was the case with call boxes, the reason can be traced to source of funding. Historically, money for aid to projects of this type has been available through DOT related channels, and as such, DOTs have played major roles in this respect. I addition, point facility operators have also been able to use these funds and tollways have been able to support systems by their own source of funding. Two other reasons may help to explain this. First, this type of detection is different froy the traditional police enforcement role, and secondly the police do not typically build freeways or associated motorist aid systems. In addition, the requisite expertise in terms of traffic engineering capability, particularly for the use of loop detectors, is usually not resident in law enforcement agencies.

As has been previously the case, cost plays a major roles as an issue, as does effectiveness. Due to the somewhat diverse nature of the two elements of this option, each element will be discussed separtely with respect to each of the issues.

CCTV. The cost of CCTV can vary a great deal. In general, a total system with one camera, mounting, transmission link, and monitor will have a capital cost of about $20,000, annual power operating cost of $100, a yearly maintenance cost of about $1,000 (198) (1971 costs) and manpower cost of $50,000 per year.[7] Obviously if a structure already exists onto which the camera could be mounted, then the cost might be less. On the other hand, if nothing is available and an extremely long pole were needed, the costs could be much greater. In general, the costs are somewhat sensitive to the specific features of the proposed location.

Location and cost also affect system effectiveness.[8] The greater the height of the camera (within certain limits) the greater will be the visability. One source (198) indicates that it is possible to obtain about four miles coverage (two miles in each direction) with one camera. This assumes that syfficient light is present and that snow, fog, or other weather problems do not interfere with the camera. A low, light camera may be the solution to the former, but there does not seem to be a solution to the

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[7]Manpower assumes five days a week, three shifts of $15,000 operators with a $5000 benefit package. More than one monitor could be observed.

[8]Operator attentiveness is also a factor that must be considered, but is difficult to measure.

latter problems. This fact compounds the limitation since during inclement weather greater numbers of incidents are likely to occur and therefore there is a greater need for a detector.

Loops. Neither weather nor the availability of light poses problems for loops. However, this type of a detection system does have problems with cost and effectiveness, which perhaps are of a greater magnitude than those of CCTV.

The cost of large scale freeway detector installation can vary from less than \$500 per detector to about \$1000, depending upon site conditions. The cost of transmitting and receiving equipment can vary from \$300 to \$500 per detector. Computer cost in terms of both hardware, software, and output is difficult to estimate, but the purchase cost of a computer to perform the necessary operations could vary from \$50,000 to about \$400,000, depending upon the number of detectors and the type of output required. Manpower costs can be assumed to be \$25,000.[9] Physical facility costs are assumed to be resident within the operating agency and maintenance costs are assumed to be about 10 percent per year for each of the above capital costs. It is readily evident that the system costs are a function of the length and the number of lanes of the facility to be covered.

At least one source has indicated that, given an interchange spacing of less than one mile (1.6 kilometers), about six or seven mainline loops per mile of a six lane facility provide adequate coverage for traffic control purposes (from a PMM&Co. interview with the Illinois DOT). For comparison purposes,[10] a six lane bridge which is four miles long is assumed to be the extent of a hypothetical system. If six detectors per mile were used, manpower remains as above, a \$50,000 computer was used, and an average of the above respective detector costs was used, total system cost would then be approximately \$102,600.[11] From this admittedly simple example one could suggest it appears that the loops are a bit more expensive than CCTV. However, the effectiveness of the respective systems should be examined before any conclusions are made.

The effectiveness of loop systems can be hampered in two ways. In the first instance the actual loop itself can be rendered inoperative.

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[9]These are the same assumptions as were made with CCTV. However, full time attention is not required and therefore other tasks can be performed.

[10]Assuming that an incident detection system would require a similar number of detectors.

[11]Annual maintenance and operation costs are about \$8,000 (10).

PMM&Co. determined from interviews that a 2 to 3 percent failure rate is common and that it is not a major problem. The second failing is somewhat more subtle but has a much greater influence upon effectiveness. False alarms with respect to the system algorithm are cited more often in the literature than any other feature. On the surface, a 1-percent false alarm rate seems reasonable. However, consider the 4-mile, 24-loop system above. Assume that each detector is queried once a minute, which gives 1440 responses an hour. A 1-percent false alarm rate produces 14 spurious reports an hour or about three per mile. In practice, a 0.01-percent false alarm rate may even be too large for a big freeway surveillance and control system.

One subtlety concerning detection algorithms and false alarms needs to be understood. There is a trade-off between the probability of a false alarm and the probability of not detecting the incident. For example, the widely used California model has the following vital statistics: at zero probability of false alarms the model has a 0.4 chance of not detecting the incident. On the other hand, to achieve a zero probability of detection failure the same model has a false alarm rate of 0.031 (187, 166). In the above example, this false alarm rate translates into 44 false alarms per hour or about 11 per mile per hour. Obviously, it is difficult to relate the desired level of reliability to cost. However, the purpose of this discussion is to relate the problems associated with this equipment and not to suggest what might be the solution to this inherent problem.

Assessment

PMM&Co. believes that under the terms of this research effort, loop detectors and cameras can only qualify as detectors for point facilities or other single point high incident areas. However, even under this restraint, serious reservations are held with respect to the individual worth of each option. The reservations are largely with respect to each of the system's effectiveness problems. One solution to the problem may be to use both in combination since each system's major weakness is complemented by the other system's stronger points. However, doing this could cause the cost of detection to rise dramatically for any facility.

Observers

Observers are people in vantage points or in direct contact with the public who are able to report incidents based upon either first hand knowledge or direct contact with someone who has first hand knowledge of the incident. It is not current practice to use this type of detector to a great extent, due primarily to circumstances which have to be of a prescribed nature before this option is viable. This option has a somewhat limited applicability and potential.

Spectrum

This particular option has no common parameter to describe its spectrum. Rather the three elements of this option will be presented simply as discrete elements. The three types of elements to be discussed are observers in vantage points, stationary service patrols, and toll collectors, obtaining incident information of toll booths.

Observers in vantage points are in the majority of the cases persons in dwellings that are located above and within seeing or telescope distance of a major interchange or a significant portion of freeway. In one instance, PMM&Co. visited a site where an observation tower had been constructed at a major freeway interchange, specifically for this purpose. Yet another type of observer used by another agency employed students on a part time basis and stationed them at strategic overpasses to report incidents as they occur. Finally, certain single point facility operators employ observers in strategic locations in tunnels.

A variation from individuals in fixed locations without transportation is observers in parked response vehicles who respond to the incident upon detection.

The final option involves only facilities that offer manual toll collection. In this case, the motoring public simply reports incidents as they pay the toll and then the toll collector forwards the report to a central dispatcher for appropriate action.

Issues Common to All Organizations

Detection issues important to this option are cost and effectiveness. Cost is a problem because it can vary so much. Effectiveness is an issue because it is usually limited by line of sight, which is affected by weather, light, and vehicles in the immediate area of the incident. Both of these factors will be discussed with respect to each of the elements.

A vantage point is required for observation. At one site an eighty-foot tower was built at the intersection of two freeways. Visibility was about one-half mile in each of the four directions. The cost of the tower was approximately $80,000. Without the aid of telescope or binoculars visibility is extremely limited at the outer perimeter of the surveillance area. At dusk or dawn the sunlight is so intense that it is only possible for short periods of time to view incidents in three directions. Effectiveness is also hampered because it is impossible for one person to simultaneously view all four sections of freeway. Thus, if two incidents occur at the same time in opposite directions, one will most likely be missed or

only detected after attention is diverted from the first incident. Night time detection is similar to detection with loops in that it is evident that something has happened, but the exact nature of the incident is impossible to ascertain. Data on the effectiveness of this and the other detectors in this section are nonexistent both in the literature and in the field. Therefore, it is impossible to measure the cost in terms of detection ability and quality.

Observation from vantage points other than facilities specifically built for that purpose is somewhat more common. Observation from apartments or office buildings offers a much cheaper facility cost, particularly if it is done as a secondary or part time job by an occupant. However, unless a corner room is used, two or more observers are required to cover an interchange. Cost, is usually limited to minimum wages of part time observers unless, as at one site, it is done by volunteers. However, the same sighting problems prevalent to the observation facility are also true of this situation.

The stationary patrol observer also requires a vantage point, but in addition, access to the freeway is required. Observation is limited to one direction if the stationary patrol usually is located in such a manner so as not to cause incidents by its presence being easily noted by the average motorist. Large vehicles between the observer and the incident are also more of a problem because the height of the patrol observer is lower and so the observer has less of a chance to see over the larger vehicles. The detection capability of the patrol is also hampered by the fact that upon detection of an incident the patrol usually responds and tries to clear the roadway. Cost of this type of detection could be less than those figures indicated in the patrol section due to the fact that vehicle operating costs are less unless the vehicles are charged out on the basis of hourly use. Finally, weather and light conditions also play an important role in limiting the effectiveness of this type of detection.

Only one limited type of observer detection was found where weather and light did not affect the observer. This was the case of observers in tunnels. Observers in tunnels are usually paid a salary and are usually trained in other aspects of tunnel operation and as such are not full time observers. For example, fire fighting and traffic management can be functions that are performed in addition to detecting incidents. Their effectiveness is limited in most cases by line of sight because many tunnels have either a vertical or horizontal curve in them.

Organizational Specific Issues

Using the motoring public to detect incidents and report them to a toll collector is obviously limited to toll facilities. No data have been collected in this respect. However, several subjective opinions obtained during the course of the field visits indicated that to make full use of such information requires a great deal of central coordination.

The need for the central coordination requirement stems from the fact that the average motorist will usually over report the severity and under report the facts as to exact location, auto description, lane occupancy, and several other very important items of information central to dispatching the correct type of response. Central coordination is also required due to the fact that if the incident is visible from both directions of travel, then the toll facilities on both sides of the incident will receive reports, thus compounding the central dispatcher's problem of resolution.

Another related factor is the fact that toll collectors are often busy and as such may tend to misreport the facts that were given to them. This lack of perfect data on the specific incident results in too much or incorrect response. Toll operators with a keen eye toward offering a superior level of service usually tend to send too much response and thus may incur greater numbers of gone-on-arrival incidents and thus greater costs for response functions than would normally be expected.

In contrast, the cost of getting the information is very little due to the fact that toll collectors are already present and communication equipment is also usually present for security and other management purposes. Again no data are available to suggest the true marginal costs of obtaining the detection data.

Assessment

It is difficult to quantify an assessment without any concrete data, so the assessment of this type of detector is largely subjective and based upon conversations with agencies that employ observers to detect incidents. An observation tower is probably the most effective type of facility due to its proximity, but it is difficult to imagine spending $80,000 for each troublesome interchange or freeway section given the limited effectiveness of the entire concept. Stationary patrols are about as expensive as mobile patrols, which have been discussed previously, and are about as effective. Using students or retired individuals on a part time basis in vantage points is attractive. However, the effectiveness of such a method is at best somewhat marginal. Finally, using the motoring public as detectors and relying upon their memory and a toll collector's correct interpretation of what was

said requires at minimum a sound central dispatching function. The capability may be improved with handout literature or with signing, but this is pure speculation due to the lack of data.

In summary, this type of detection appears to be somewhat ineffective at least from a subjective point of view. Its most effective application may be as a supplement to some other type of detector.

SUMMARY

The detection options presented in this chapter were call boxes, both voice and push button; patrols, including service patrols, police patrols, motorcycles, and others; CB radios; observers;and electronic systems consisting of loop detectors and closed circuit television.

Call boxes were found to experience relatively low usage with operating and capital costs that seem to be greater than those of other detection options with equal or greater detection potential. Of the various types of patrols, the dedicated freeway police patrol appears to have the most to offer, when all aspects of the FIM system are considered. Service patrols probably would serve the need in the absence of police patrols. However, it is doubtful that many cities could afford such an investment on a continuing basis. Motorcycles are probably best suited for detection in high incident areas, however a demonstration would be necessary to prove their worth in terms of the total FIM environment. If aircraft are available at no cost to the FIM system, then they can be of use. However, the usefulness of aircraft to FIM operators does not appear to warrant their purchase solely for freeway incident management. CB radio systems appear to be the best detector from the standpoints of cost and coverage. The CB organizational cost and its operational drawbacks are the issues of greatest concern. CCTV and loop detectors are probably best suited for point facilities. However, serious reservations are held with respect to the individual worth of each option. Finally, observers were judged to be somewhat ineffective from a subjective point of view. Their most effective application may be as a supplement to one of the other detection options.

CHAPTER 4

IDENTIFICATION OF ON-SITE FREEWAY INCIDENT MANAGEMENT PROBLEMS

An integral part of the investigation of the incident management problem was the observation and analysis of the occurrence of actual incidents. By this means the problems and needs, identified through interviews with incident management participants in the various cities, were verified and expanded upon. In this chapter, the data collection procedures are described, problems are presented, and potential countermeasures are suggested for the traffic control related problems. The administrative, organizational, and preplanning problems identified are discussed in Chapter 5.

DATA COLLECTION METHODOLOGY

Two means of incident observation were used. The first consisted of the on-site observation of incident activities in real-time by one or several persons. The second involved the extraction of data from videotapes of recent incidents in two major cities. Fifteen incidents were observed on-site and 15 via videotape.

On-Site Observations

The 15 on-site observations of incidents took place in several different areas of the country, but primarily in the East. They ranged in scope from highly congested urban freeways to less congested suburban areas. They also varied in terms of time of day, roadway condition, and geometric characteristics. The major characteristics of the 15 incidents are shown in Table 2.

The basic elements of the data collection methodology for the on-site observations included receiving notification of an incident occurrence, observing on-site activities, interviewing the involved persons after the incident, and finally, reconstructing the events of the incident. Interviews were not conducted for some of the incidents, as sufficient information was available from the observation of on-site activities to reconstruct the traffic control and site clearance aspects of the incident. For others, extensive post-incident interviews were conducted, giving a greater amount of data and insight into the organizational-type problems which were encountered.

TABLE 2

SUMMARY OF ON-SITE AND VIDEOTAPE OBSERVATIONS

DESCRIPTION OF INCIDENT	FREEWAY TYPE				FREEWAY LOCATION			FREEWAY SITE CONSTRAINTS			TIME OF OCCURRENCE			INCIDENT DURATION				EXTENT OF BLOCKAGE			ALTERNATE ROUTES USED			INCIDENT SEVERITY				EQUIPMENT REQUIREMENTS					JURISDICTIONS INVOLVED			
	4-Lane	6-Lane	8-10 Lane	Interchange or Ramp	Inner Urban	Suburban	Rural	None	Bridge	Construction	Peak Period	Midday	Night	<1 Hour	1-2 Hours	2-5 Hours	>5 Hours	1 Lane	≥2 But <All	Complete Closure	None	Indirect	Direct	Fatalities	Major Injury	Minor Injury	No Injury	Police, EMS, Tow	Fire	Special Tow	Debris Removal Eq.	Other	City	County	State	Federal
On-Site																																				
1. Gasoline Tanker Acc.—Fire			x			x		x					x				x			x		x		x				x	x	x	x	x		x	x	x
2. Trash Truck, 2 Autos—Fire	x					x		x				x				x				x			x	x				x	x	x				x	x	
3. Disebled Crane			x		x				x			x			x				x		x						x	x		x			x	x		
4. 2 Tractor Treilers—Fire		x				x			x				x				x			x			x			x		x	x	x	x			x		
5. Disabled Auto		x			x			x					x	x				x			x						x	x					x			
6. 2-Car Collision—Ice	x					x				x		x		x				x			x						x	x						x		
7. 4-Car Collision		x				x		x			x			x				x			x						x	x					x		x	
8. Disabled Grader				x		x		x				x			x			x			x						x	x		x					x	x
9. Overturned Dirt Truck		x				x		x				x				x			x		x						x	x	x	x	x		x		x	
10. Multiple Bus/Auto Collision—Exclusive Lanes						x					x					x				x		x				x		x	x	x				x	x	
11. Rear-End Collision—Right Lane	x					x		x			x			x				x			x						x	x					x			
12. Rear-End Collision—Median Lane	x					x		x			x			x				x			x						x	x					x			
13. Overturned Tanker—Hazardous Materiel		x					x	x					x				x	x			x					x		x	x	x		x			x	
14. 2-Car Collision—Rain		x				x		x					x	x				x			x					x		x					x		x	
15. Truck/Car Collision—Rain	x					x				x		x		x				x			x						x	x	x	x					x	
Video																																				
16. Overturned Tractor Trailer			x		x			x				x				x			x				x					x	x	x	x				x	
17. Overturned Truck			x		x			x				x		x					x		x							x							x	
18. Overturned Truck/Auto Collision			x		x			x			x				x				x				x					x		x					x	
19. Car Plunged Down Embankment			x		x			x			x				x			x			x							x							x	
20. Rear-End Collision—3 Vehicles			x		x			x				x		x					x		x					x		x							x	
21. Dump Truck, 6 Other Vehicles			x		x			x				x			x				x		x							x	x	x					x	
22. Disabled Vehicle			x		x			x			x			x				x			x						x	x								
23. 7-Vehicle Collision			x		x			x			x			x					x		x							x							x	
24. Overturned Auto			x		x			x			x			x				x			x							x							x	
25. 2-Car Collision			x		x			x			x			x				x			x							x							x	
26. Rear-End Collision—2 Autos			x		x			x			x			x				x			x						x	x							x	
27. Bus/2-Car Collision		x			x			x			x			x				x			x						x	x							x	
28. 4-Vehicle Collision			x		x			x				x		x					x		x						x	x							x	
29. Single Auto Hit Guard Reil	x				x			x				x		x				x			x					x		x							x	
30. Rear-End Collision		x			x			x				x		x				x			x						x	x							x	

Videotape Reviews

Videotape observations of 15 incidents were obtained from operations on the West Coast and from the Midwest. The incidents ranged in scope and varied in terms of time of day, road condition, and roadway geometric much as the on-site observations. The major characteristics of these incidents are also indicated on Table 2.

The incidents observed had been videotaped from two distinct vantage points. In one city, the view was from a helicopter which had been dispatched to view and record the incident for in-house training purposes. In a second city, the view was from one of a number of fixed closed circuit TV installations along the freeway.

The events and times observed were then documented in the same format as were the on-site observations. In most cases, the videotapes were supplemented with a brief written summary of events. Especially useful were the data on the cause of the incident, the location, and the types of problems encountered. In many cases it was also possible to extract traffic count data from the tapes which were useful in measuring roadway capacity reduction for various incidents.

PURPOSE AND USE OF DATA COLLECTION

The five specific uses of the incident data can be summarized as follows:

- First, the incident investigations served to orient the project team as to current incident management techniques and the types of equipment typically used. The investigations put the team in close contact with those actually performing the on-site incident activities.

- The second use was to identify some of the more frequent and more critical shortcomings of on-site incident management. This exercise was limited to a sample of 30 incidents observed, so it is difficult to conclude that these findings represent the total incident population. However, the incidents did point out problems which might not have surfaced had this work not been done.

- Third, since the incidents were observed in a number of different jurisdictions, the activities performed by each were compared. A range of differences in freeway incident management systems could then be identified. This

informaton was most valuable in gaining a perspective of those systems not employing the more advanced incident management approaches.

- Some problems identified lie outside the range of on-site incident management. This served a fourth purpose of categorizing those problems which must be addressed on different fronts. These involved changes in the organizational, administrative, and preplanning activities of various actors (see Chapter 5).

- The fifth use of the incident data was to gain knowledge as to which areas hold the greatest potential payoff for improved freeway incident management strategies. In addition, some problems which appear to be easily overcome may, upon closer scrutiny, prove to be extremely complex. The incident data were quite useful in drawing out some of these facts.

ANALYSIS PROCEDURES

The first step in the data analysis was to list specific problems which occurred at each of the 30 incident sites. This yielded a compilation of problems which reflected local conditions, including geometric characteristics, time of day, weather, equipment available, organizational problems, jurisdictional conflicts, etc. Commendable features of the incident management procedures were also compiled for each event.

The analysis was not restricted only to the on-site activities but was also extended to other less visible activities which may have had an influence on the efficiency with which the incident was cleared (e.g., communications). These latter types of problems sometimes were evident at the incident site but more often were identified in the follow-up contacts with those people involved in the incident.

All of the individual problems were then compiled and trends and patterns were identified. These trends fall into definite categories, as listed below:

- detection and verification;

- supervision of on-site activities;

- traffic control and driver information techniques;

- equipment and manpower requirements; and

- interagency cooperation.

The last four categories pertain primarily to the response mechanism of the incident management process. The identification of problems in the areas of incident detection and verification was not a major aspect of this portion of the study. However, some brief, general comments on observation in the detection area are presented below. Following this is the detailed discussion of problems and potential countermeasures in each of the four major categories. It should also be noted that guidelines are to be developed in later phases of this contract to assist personnel in handling on-site problems.

Detection and Verification

Although the detection and verification function was not actively pursued while each incident was being observed, an assessment of the detection time was made by means of follow-up interviews. These interviews indicated a general trend related to incident severity.

The incidents observed were all detected by citizens and covered a broad range of severity, from accidents involving multiple fatalities to those involving a single disabled vehicle. For the more serious incidents, the detection and verification time seemed to be consistently less. Those incidents which were less serious appeared to take a significantly longer time to detect. The reason suggested is that a citizen has a greater sense of urgency to report a more serious incident. Although almost every citizen will make an attempt to report an extremely serious incident, a large percentage of citizens do not bother to report a more minor incident such as a disabled vehicle. This characteristic of detection time appears throughout the 30 observations.

Improving the detection time for incidents of minor severity is an important task. Although the impact on traffic flow will usually be much less than for the larger incidents, it is critically important to deal with less serious incidents because of their much greater frequency (see Chapter 6). Potential methods of addressing the detection problem have been discussed in Chapter 3 of this report.

Supervision of On-Site Activities

Formulating the plan for on-site incident management activities is affected by two factors. First, the plan is dictated by the stated policies of the agencies in the jurisdiction in which the incident occurs.

These may be policies of the police department, state highway department, or other agencies or combinations of agencies. Those personnel directly involved in the supervision of a specific incident are bound by the policy governing that situation. The second factor governing the quality of actions taken at an incident scene relates to the knowledge and experience of those directly involved. To a large extent, this is a function of the training which has been received and experience which has been gained in incident management activities. The quality of actions taken is often dependent on the personnel who happen to be handling a particular incident, as overall training, experience, and ability levels may vary considerably from person to person.

The supervisory role in the on-site incident management, whether the supervisor be a police officer at a minor incident or a management team at a major incident, is primarily concerned with the actions involving:

- assessing needs;
- setting priorities; and
- arranging for services.

Both effective and ineffective procedures observed during the course of the data collection with respect to each of these areas are discussed below.

Assessing Needs

During each incident there was at least one point at which the need for equipment, personnel, and actions had to be determined. For minor incidents this need assessment period was very short, whereas for major incidents it was quite long and continued throughout the duration of the incident. At the minor rear-end collisions and disabled vehicles observed, the assessment of needs was performed almost instantaneously upon the arrival of police. At the accidents of medium severity, such as incident numbers 7, 14, 15, 21, 24, and 28 in Table 2, more factors had to receive consideration, including medical and possibly fire equipment requirements. At the most severe incidents (numbers 1, 2, 10, and 16), the scope had to be expanded to include heavy-duty site clearance equipment, extensive traffic control strategies and in some cases special services such as telephone and power companies.

The assessment of needs at an incident was seldom a problem for those incidents of smaller magnitude. It was more often a problem at

major incidents since several agencies were involved, causing the organizational and supervisory roles to become more complex. For many of the incidents, only the police, with minimal wrecker assistance, were involved. For the most severe incidents observed, many organizations were often involved. For example, at incident number 1, involving a gasoline tanker fire, the following agencies were present:

- County Police
- State Police (two states)
- local fire department
- local rescue service
- coroner
- private wrecker company
- private truck firm (owner of truck)
- U.S. Air Force base personnel
- State Highway Department maintenance crews
- State Highway Department bridge engineer
- power company
- telephone company
- local radio station

The assessment period for determining the needs of some of the services was very brief. For instance, if power and telephone lines were down, obviously the utility companies were required. However, the requirements for items such as site clearance and traffic control were far from obvious, as there were many additional factors to be weighed in making decisions. The failure of the private trucking firm to provide a replacement truck in timely fashion resulted in additional needs assessment beyond what was initially deemed necessary. Since extensive route diversion was involved in this incident, needs assessment for traffic control did not cease until the incident was completely cleared.

Assessment of needs appeared to be most lacking in the areas of traffic control, equipment, and manpower requirements for site clean-up. The difficulty in assessing needs for traffic control at the incidents arose primarily from the inability to accurately predict the impact that the incident would have on traffic flow. If the duration of the incident, the queue lengths, and the demand volumes had been precisely known, this problem could have been greatly alleviated. The lack of adequate data and the inexperience of the incident management personnel in traffic control sometimes produced poor decisions, primarily at the major incidents.

A lack of good judgment in assessing the equipment and manpower needs for clearing an incident from the roadway resulted in additional unnecessary delay at several of the incidents. A typical example found in the incident observations was that the personnel in charge requested equipment which was inadequate to clear the incident. This problem was most often encountered at incidents involving heavily loaded trucks, special cargoes, or hazardous materials.

Assessing the need for emergency rescue services and for fire apparatus was usually completed accurately because of familiarity with the services provided by these agencies. However, assessing the need for special services, such as special site clearance equipment from the highway department appeared to be slightly more of a problem. Unlike the case for fire and emergency rescue service, these special functions were only infrequently dealt with. Because the need was so infrequent, those assessing needs seemed to be less aware of the capabilities of these services and when to summon them to the scene. Undoubtedly the best countermeasure for weakness in the area of needs assessment is experience and training.

Setting Priorities

Concurrent with assessing the needs at an incident is the establishment of the priorities of those needs. Typically, the priorities are self-evident; however, many times a conflict between various needs arises.

One of the major conflicts is that between the requirements for accident investigation and the desire for rapid removal of the vehicles and debris. Police are often confronted with this problem since they must satisfy various legal obligations while at the same time maintaining traffic flow. At incident number 7, at least 15-20 minutes could have been saved if some of the investigative functions had been performed off the freeway lanes. For several other incidents, smaller amounts of time could have been saved.

Judging from the incidents, the variance in procedures for the clearing of incidents is quite large. Most of these variations appear to be dictated by incident management policy rather than by differences in procedures among individuals. In some areas, high priority is placed on removing the vehicles from the roadway as quickly as possible. In other areas, more emphasis is placed on accurate investigative data; rapid removal is less of a concern. The major problem is whether the additional insight gained into the legal aspects of the accident is worth the additional delay to the motorists. One advantage of rapid removal is that it may prevent secondary accidents from occurring.[1]

Other conflicts in setting priorities did occasionally arise, but these were usually specific to an individual incident, and definite patterns could not be established. An example of one conflict which arose involved a car down an embankment (incident number 19). In order to recover the car at the time of the incident, traffic would be severely impacted, but recovery would be more difficult later. The decision finally made was to recover the car immediately and suffer the traffic consequences.

The setting of priorities is usually a policy level decision, determined before the occurrence of an incident. Therefore, any countermeasure must be addressed toward the area of incident management policy. Those persons on the scene are limited to the policies previously set forth and can exercise little flexibility over how those policies are carried out. This element is discussed in Chapter 5.

Arranging for Services

Once the needs have been assessed and priorities set, the services required must be contacted and summoned to the scene. This was almost a continuous process in many of the incidents observed, particularly the most severe incidents.

Problems in arranging for services are intensified as the magnitude of the incident increases. Again, this is due to the greater number or agencies, personnel, and equipment required to handle a major

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[1] It has been suggested that the secondary incident rate is about 9.75×10^{-4} incidents per emergency stop (213).

incident. It was found that it was easier to arrange for those services which were required more frequently, such as emergency rescue services, fire departments, and wrecker services. Special services, such as the public utilities previously mentioned, and highway department maintenance equipment and personnel were the most difficult to contact and summon to the scene. Even though the dispatcher may have the phone numbers of those services, the exact location of personnel and equipment required to deal with the problem were often unknown. Dealing with freeway incidents is not a primary concern of these special services, and consequently they were often not prepared to mobilize for such an event. Although incidents in which these services are necessary were rare, the additional delay introduced in clearing such incidents was frequently significant.

The difficulty of locating the equipment and personnel required at the scene was one contributing factor to the problem, but perhaps more significant is the fact that these personnel, usually out in the field, cannot always easily drop their task at hand. Personnel must either be summoned from an area further away, or additional time allowed for the task to be completed. Aside from furnishing completely separate units for these emergency purposes, the problem is very difficult to solve. The infrequency of these events would make such preparations extremely impractical.

The most severe problem in this area has to do with the involvement of private companies whose vehicles are involved in the incident. Most commonly, this will be a truck carrying cargo such as gasoline or other hazardous material. At incidents 1 and 13, cargo had to be completely emptied into a second truck before a truck could be removed from the roadway. In one case, almost 24 hours elapsed before the second truck and personnel knowledgeable in the transfer of the material could reach the scene. In this latter instance, the personnel had to be flown from over 1,500 miles away, and the second truck had to be summoned from outside the state, several hours away.

Strong private sector services coordination, page 92, a detailed FIM dispatcher's manual, page 108, and good relationships with other organizations, page 95, could alleviate some of the problems in arranging for services.

Traffic Control and Driver Information Techniques

One of the primary purposes of the incident data collection was to observe the methods by which traffic was controlled at the site and the types of driver information techniques and devices which were used.

This type of data has seldom been collected through any means, including accident reports. If the goal of freeway incident mangement is to reduce traffic delay and increase safety, traffic control must be a primary consideration in any incident mangement system. The categories which have been covered in this section include:

- use of vehicles at the incident site;
- use of flares, cones, and other lane closure devices;
- manual merging techniques;
- advance warning for motorists;
- determining extent and means of lane closure;
- forecasting the impact on traffic flow;
- implementing diversion procedures; and
- providing information through the media.

These activities were most often included in the traffic control procedures at an incident site. Some of these, such as diversion procedures, were used only for certain types of incidents and roadway characteristics. Others, such as the use of vehicles at the incident site, were always a consideration no matter what type of incident was involved. This list does not suggest that problems were discovered in each of the areas covered. Rather, the attempt here is to discuss not only the problems but also the commendable features of the incident management activities.

Use of Vehicles at the Incident Site

The use of vehicles at an incident site involves the location and method of parking those vehicles to protect the incident scene.

It was almost always found in the incident observations that a police vehicle was parked directly behind the scene of the incident with warning lights activated. The angle at which the vehicle was parked and distance behind the incident scene varied but in almost all cases, the vehicle was in a position to protect the involved vehicles and warn oncoming motorists. Judging from the incidents observed, no severe problems exist in this area and methods are quite consistent. However, considerable differences in practice exist with respect to leaving police emergency lights on or off after the incident is moved to the shoulder.

In some instances, flashing lights were left on; in others they were shut off. The difference involves a trade-off between warning on-coming motorists of the incident and increasing "gapers block," which may further reduce traffic flow past the incident (82) or even increase the potential for secondary incidents. In most of the areas in which incidents were observed, more emphasis was placed on warning the motorists. Consequently, the lights were generally left on.

Because the site protection element of on-site incident management is currently satisfactory, it would appear that there is little opportunity for improvement in this area. However, the flashing light policy is discussed in Chapter 5, page 96.

Use of Flares, Cones, and Other Lane Closure Devices

Initially, the incident itself serves as the instrument by which a lane or lanes are closed. However, it is desirable that the lane closure be performed in a systematic manner so that motorists have warning as to what is confronting them and what actions should be taken. This very frequently involves the placement of flares, cones, and other devices to efficiently merge traffic to allow it to flow around the incident. This section discusses how effectively these devices were used in the incidents observed and potential ways in which the problems can be relieved.

Based on the incident observations, the use of lane closure devices is most critical if speeds approaching the incident are high, and if certain vertical and horizontal road curvature is involved. The most serious problems involved incidents which had occurred during the offpeak hours and did not reduce capacity enough to initiate the information of a queue. Since drivers facing this condition must make decisions very rapidly, the devices controlling the merging of traffic and bypassing of the incident must be placed in an optimum position. Where a queue did exist (as it did in most of the incidents), speeds approaching the incident itself were much lower. In these cases, drivers had more time to assimilate the information required to merge into another lane and to bypass the incident. This is not to say that the use of flares and cones was not important at the incidents involving queues, but the safety implications at the incident were much greater where a queue did not exist.

A general conclusion derived from observation of the incidents was that flares were put to use at the appropriate times but that the method of use gave motorists inadequate warning. Two of the incidents which took place in darkness with no queue presented particular problems. Areas in which the use of flares and cones can be improved include the lengths of tapers, spacing the devices, and how they are set out.

The primary method for improving these techniques is more rigorous training. The training requirements for something of this nature could consist of several hours of classroom time. Another aid might be the use of easily carried reference materials such as plastic coated cards which could be pulled out for information on setting tapers for various circumstances. The impact of this problem is not large and the expenditure required to improve conditions is quite small.

Manual Merging Techniques

Manual merging techniques refer to traffic direction by personel at the site, whether they be police officers or private citizens.

In no instance during the course of the incident observations were unsafe manual merging practices found. All the techniques observed were performed by police or highway department personnel. The police personnel appeared to be well-trained in conveying manual messages to motorists. Motorists almost always seemed to be aware of when they were to stop and start their vehicles. The question raised by the incident observations, however, is whether the merging techniques used provide the greatest capacity possible through the restricted area. Traffic flow data obtained at several incidents indicate that free merge unsupervised by police officers increased flow past the incident by as much as 20 percent.

Since the manual merging techniques currently being used seem to be adequate for safety purposes, there is little likelihood that there would be any gain by putting effort into this area. Increasing traffic flow, however, can be achieved by limiting the usage of manual merging wherever possible.

Advance Warning for Motorists

This section describes the means by which motorists approaching an incident, or the queue caused by an incident, are warned to reduce speed. This message can be communicated in a number of ways including fixed signs along the roadway, signs on vehicles, flagmen along the roadway, flashing lights on a vehicle at the scene of an incident, or with many other types of warning systems. The most important aspect is that the motorist has this warning far enough in advance of the incident that he may slow his vehicle to the speed of the motorists bypassing the incident.

The provision of advanced warning for motorists approaching an incident was found to be one of the most severe deficiences in the incident

management systems observed. The basic reason for this is that without some type of very flexible advanced warning system available, such as vehicle mounted signs, the implementation of such warning is only feasible for those incidents which are of long duration, i.e., an hour or more. Supplying the required information in exactly the right position along the roadway is essential, but is difficult unless a mobile warning system is available. In most of these cases, the only advance warning that is provided is the flashing lights on a police vehicle or the taillights of downstream vehicles.

At few of the incidents observed was there any attempt to warn oncoming motorists of the incident or of the queue caused by the incident. At one incident of long duration, where a truck was blocking one lane, standard construction signs were used to provide advance warning. Even at the incidents involving diversion, little advance warning was used aside from detour information. One of these incidents (number 4) had a severe secondary incident (overturned vehicle) which might have been prevented had a warning system been available.

Any improvement of the advance warning for motorists must involve the provision of adequate hardware. This will be discussed in a later section of this report. Some of the forms that this hardware might take have already been suggested. Advance warning systems that rely on the traditional types of portable maintenance signs are generally not flexible enough to respond to the information needs of the motorist for all types of incidents.

<u>Determining Extent and Means of Lane Closure</u>

At many incidents a decision must be made as to how many lanes of freeway should be closed or perhaps whether complete closure should be effected. This decision depends on the nature of the incident and the danger posed to the personnel involved. Usually this decision is obvious. However, in some cases, minor actions may be taken to free an additional lane for traffic flow, or to use alternate routings.

At most of the incidents observed, quick and accurate decisions were made involving lane closure. In many cases, additional capacity was provided by using the freeway shoulder. There was, however, at least one instance in which some debris could have been removed easily from the roadway providing an additional lane of traffic flow. In another instance, if the removal of a vehicle from an embankment had been delayed until the off-peak period, congestion could have been significantly reduced. The problems were usually site specific, and normally occurred because of the preoccupation of the incident management personnel with other ac-

tivities.

Improvements made in this area may involve policy level decisions, and increased training and experience. The solutions to these problems also relate to preplanning by the involved agencies, as described in Chapter 5, page 107.

Forecasting the Impact on Traffic Flow

Decisions made in traffic control must be based upon certain data. This includes the estimated duration of the incident and the resultant impact on traffic flow. This estimate will determine what types of advance warning systems may be required and whether diversion plans should be implemented. An accurate prediction of the impact will help to create a realistic assessment of the needs for handling the traffic queued at an incident.

At most of the short-term incidents observed, a more accurate forecast of the impact on traffic flow would not have altered any of the decisions made. This was particularly evident in the minor incidents because there were few, if any, alternatives to consider.

One of the primary issues emerging from the major incidents where through lanes were blocked for more than an hour, was whether traffic should be diverted from the freeway onto an alternate roadway. Several such incidents were observed in which diversion was used. In each case, some traffic delay could have been eliminated had there been an awareness of how severe traffic congestion was going to be at different time periods. Most of the predictions of the impact on traffic flow under these conditions appear to have been made subjectively. There was usually a "feeling" as to whether the impact was going to be critical. A more accurate assessment would have been valuable to some of the traffic control decisions.

At several of the more major incidents which occurred during the early afternoon, there were more immediate problems faced by the officer on the scene in estimating whether the incident could be cleaned up prior to the peak hour, and what the consequences would be if it were not. In general, the police officers did not give much thought to this problem, and had a general attitude that this factor was beyond their control. In no case did the police officer at the scene devote his efforts to a full-scale attempt to estimate the duration of the incident and its later impact on traffic flow.

The improvement in the accuracy of the impact forecasts rests primarily with the availability and use of traffic data at the scene of the incident. Such data would include the present capacity at the incident site and expected demand volume for the duration of the incident. Other elements, such as roadway geometrics (number of lanes), are also important in the analysis. Many police officers on the scene are not capable of making those decisions for major incidents. Significant improvements may be possible if these problems could be analyzed at a central location, and decisions communicated to field personnel, or if the officer at the scene had data available, and was trained to use it accurately. Guidelines for predicting the impact of an incident on traffic flow will be developed as part of this study.

Another area in which improvement is possible is that of estimating the duration of the incident. It did not appear that those in charge of any of the incidents went through the on-site management process in a systematic manner, detailing the time elements of each component of the incident clearance scheme. A more detailed analysis of the components contributing to the clearance time might improve prediction accuracy. This analysis can usually be done quickly and would be necesssary only at major incidents where traffic decisions may rest on the accuracy of the estimate. The duration estimate could then be altered during the course of the incident based on changes during the process (such as the late arrival of a wrecker, etc.). This analysis could also be done at a central location.

Implementing Diversion Procedures

The number of incidents in which diversion procedures are used are quite few (see Chapter 6). However, these incidents do cause a major portion of the vehicle delay caused by freeway incidents. Three of the primary factors in implementing diversion procedures are route selection, route information provided to the drivers, and management of the diversion system.

The type of roadway system available for diversion is one of the principal factors which influences the feasibility of diversion for freeway incident management purposes. A freeway with a frontage road will obviously be more adaptable to diversion procedures than will a freeway with few parallel roads. Similarly, many freeways may be of a design such that contraflow diversion is suitable, while median barriers and other design elements may not permit this option at other locations.

Several incidents were observed in which diversion procedures were actually implemented. All of these occurred in an area where no high

capacity alternative routes were available. In one case, traffic in one direction was allowed to use one lane of the opposing direction of traffic (contraflow operation) so that a discrete alternate route was not actually necessary. Another case involved large volumes of traffic that had to be accommodated on a very indirect alternate route, due to complete closure of the freeway. This resulted in tremendous congestion problems. No diversion activities were observed on freeways provided with frontage roads.

The selection of a diversion route was not a problem at any of the incidents observed. In none of the incidents observed on-site were any diversion routes preplanned. In each case the best possible route was eventually selected since the persons involved were familiar with the roadway network in the vicinity of the incident. The problem, however, was that the decision to divert traffic and select the alternate route was not done quickly enough. Problems encountered in mobilizing forces for diversion were the primary constraint. For additional discussion on preplanned diversion routes, see Chapter 5.

Another problem found in diversion route implementation was that of providing motorists with clear information as to how they may reach their ultimate destinations. While most of the diverted motorists were probably familiar with the area, there were also many who did not understand how to reach their destination with the information given. Drivers were particularly confused at one incident where several ramps of an interchange were closed and no alternate route signing was implemented.

Several areas of improvement were also identified in the incident which involved contraflow diversion (Figure 1 shows the basic diversion set-up). Initially there were no flares set out to separate the opposing flows of traffic. Neither was there any warning given to motorists approaching on a ramp between the crossover points that two-way traffic was flowing on what was normally a one-way roadway. These motorists entering the freeway, being unaware of the closure of the left lane, sometimes crossed into that lane, putting themselves and opposing drivers in a very hazardous situation. Once the flares were in place the condition was alleviated. It took what seemed to be an unnecessarily long time, however, before these adjustments were made.

One of the problems identified in the contraflow operation as well as at other incidents was the lack of readily available signing and other infomation devices. As a result, the diversion procedure was often labor intensive. This sometimes caused the poor use of personnel, particularly police officers whose presence may have been more effec-

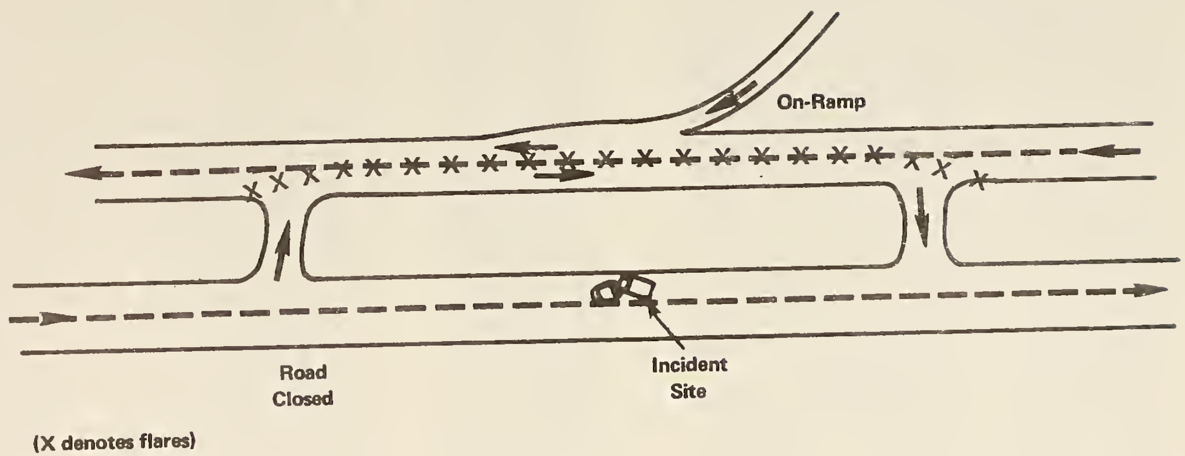

FIGURE 1: CONTRAFLOW OPERATION

tive elsewhere. This type of incident occurred infrequently, but a solution to it could save time and resources. In most cases, signs and other equipment provided more effective communication than flagmen. This was particularly true where large volumes of traffic flow were involved, because where no signs were provided, many motorists had to stop and inquire about available alternate routes.

An additional important factor is the management of activities once the alternate route has been set up. This can be a very complex process and may involve several levels of responsibility. In one case, the diversion management function was performed by a helicopter overseeing all on-site and off-site activities. This allowed quick assessment of traffic conditions and adjustment of procedures based on those conditions. In the other instances this overall view of the scene was not available, but despite this, communications appeared to be adequate, and commands seemed to be issued clearly, and carried out correctly. In one instance, however, personnel in charge of on-site activities were not aware that several highway department sign trucks which could have been used in traffic control were parked nearby and were available for use. It is suspected that if a larger sample of incidents involving diversion could have been observed, additional problems in this area would have surfaced.

The basis for improvement in handling diversion activities would ideally involve preplanning for the more catastrophic occurrences. This includes the development of specific diversion routes for each section of freeway. Plans should be comprehensive in nature and involve the cooperation of all involved agencies.

The preplanning of diversion routes is fairly straightforward. The problem of providing the equipment and manpower necessary to implement the diversion scheme is more difficult and time consuming. The solution lies with a combination of preplanning and provision of additional hardware (e.g., a signing system). The latter will increase flexibility but may introduce significant costs. Some of the more flexible and less expensive alternatives may include concepts such as: preplanned diversion route signs which can be flipped down manually; lightweight, portable arrow signs which can be fastened to other signs or poles along the freeway; or permanently mounted route markers (e.g., "To I-70") placed at more frequent intervals along potential alternate routes. Guidelines on these concepts will be developed in later phases of this contract.

An additional area offering potential benefit is the "command post" concept for use at more complex incidents, especially those involving diversion. This countermeasure is discussed further in Chapter 5, page 91.

Providing Information Through the Media

It is not uncommon for the police department to inform various radio stations of major incidents. This is most common during peak hours in major cities which have peak period traffic reports. Upon pursuing and comparing many of the reports, however, it was found that much of the information was not accurate.

The major deficiency in the radio broadcasts is that the information is often outdated and inaccurate (48). For instance, one report was aired which stated that an incident whould not be cleared until after the peak hour when in fact it had already been cleared. Obviously, this did not help the motorist in choosing the most effective route. At other times the wrong information was given with respect to the exact location and direction of the incident. This was the result of either wrong information given by the source or the information being transmitted unclearly.

The amount of effort that must be expended in transmitting accurate information from an on-site source to the ratio should be quite small, but is extremely important. Further discussion on typical problems encountered with the use of commercial radio for freeway incidents can be found in reference 48 and on page 104 (Chapter 5).

Equipment and Manpower Requirements

The success with which each incident is managed is dependent on the equipment available and manpower provided. These areas are key to the incident management process. In this category, the requirements have been broken down in terms of emergency services, traffic control devices, and site clearance equipment.

Availability of Emergency Services

Emergency services would include those agencies which normally respond to incidents such as ambulance, wrecker, fire equipment and those who would respond only in unusual circumstances such as utilities and special equipment.

Few problems were found to exist in this area of the incident management structure. The emergency service systems were well estab-

lished in all areas where incidents were observed. Minor problems concerned the availability of wrecker services during the off-hours. Response times at night and on weekends seemed to be somewhat longer than during normal working hours. Response times for fire and ambulance equipment was quite consistent regardless of the time of day or the day of the week. Some suggestions are made on page 92 regarding this problem.

For cases involving the need for special or unusual equipment, several communications problems were found to exist. In an incident where a large military vehicle was involved, a call for help was relayed to a nearby base requesting special towing equipment. The equipment did not arrive, however, until after a representative from the military base first visited the scene to verify the request, and approximately an hour was lost in removing the equipment. Communications misunderstandings of this type were observed infrequently, but indicate the types of situations that arise in unusual circumstances and can cause considerable delay.

Availability of Traffic Control Devices

Some of the problems of traffic control devices which surfaced during the incident observations have already been discussed. Much more could have been done in the areas of advanced warning for motorists and alternate route information. If additional signs and other traffic control equipment had been available at the incident sites, the level of safety would have certainly been improved and some delay eliminated. However, any significant traffic control benefits would include extensive preplanning and the purchase of additional hardware, both expensive alternatives.

Three specific areas of countermeasures are discussed here. The first is concerned with on-site traffic control devices such as flares and cones. The second is advance warning for the motorists, most often including signs. Finally, the possibility of signs indicating diversion routes is addressed.

The primary use of cones and flares is for closing a lane or lanes of traffic in a way that will allow the safe and efficient merging of vehicles. At all of the incidents observed, flares were the primary means of accomplishing this. In only one case, an incident of fairly long duration, were cones used. The reason why cones were not often used is that they are often not considered to be an "emergency" device or because they take up a great deal more space than flares and are more difficult to store in the trunk of a police vehicle. Judging from the con-

ditions surrounding the observed incidents, either device would have been adequate during daylight hours. At night flares have a distinct advantage. The major advantage of cones is that they can be used over and over again, causing a significant reduction in cost outlay. In addition, flares burn out (usually in about 30 minutes) and must be replaced for incidents of long duration, creating additional hazard for those persons placing them.

Police officials find the storage of the cones a problem. One solution might be to stockpile cones in equipment caches at different locations along the freeway so that they are more readily available than if they were supplied by a highway department maintenance team. At the majority of incidents, no more than 10 cones would be necessary.

Another device for effectively merging traffic into a reduced freeway width is an electronically lighted arrow which can be mounted on a vehicle and raised to a fairly high level so that it can be seen far in advance of the incident. The arrow indicates the direction the vehicles must move to bypass the incident, thus eliminating the need for cones and flares. These were not observed in any of the 30 incidents but have been used extensively in many parts of the country. The safety advantages and reduction in manpower are two frequently cited positive aspects of this device.

The solution to advance warning and alternate route information could be very costly if a sophisticated system is to be devised. The requirements of an advance warning system are that it should be flexible and have the capability of providing messages sufficiently far upstream of the incident to warn motorists. The requirements for diversion signing are that the information be clear, accurate, and visible.

Two basic concepts for providing the information desired are a fixed sign system along the side of the roadway or a movable sign system involving signs mounted on vehicles or portable signs. The messages provided by either of these systems may either have fixed or variable messages. No attempt will be made to completely catalog the alternatives here. The point is that any improvement achieved in the realm of advance warning or diversion information will probably be at a high level of capital investment.

The manpower required to control traffic at freeway incidents depends on the type of devices available. In some instances, the provision of a more advanced signing system may eliminate the necessity for some personnel to be at the scene. On the other hand, the use of some additional traffic control equipment (e.g., signs mounted on vehicles to be

used in advance of the queue), would require that more personnel be available. A general observation of the more serious incidents suggests that more personnel are on the scene than are actually required for traffic control.

Availability of Site Clearance Equipment

Site clearance equipment includes equipment that may be needed to remove an incident from the roadway. This may range from push bumpers on a police vehicle to front-end loaders or cranes to remove debris.

There are two aspects of the availability of site clearance equipment to be discussed. The first is whether the equipment is, in fact, available from agencies in the vicinity of the incident. The second is how readily the equipment can be located and summoned to the scene.

Equipment that was used for incidents in which vehicles could be pushed or in which debris had to be cleared was usually available somewhere in the area. Where private wrecker services could not perform the cleanup operation alone, the highway department provided heavy duty removal equipment such as front-end loaders and dump trucks. The major problem found to occur was that the equipment was often being used for other purposes, sometimes in areas remote from an incident.

There were a number of incidents observed in which the provision of additional equipment could have greatly reduced the site clearance time. One equipment option is push bumpers that can be installed on the police vehicles that patrol the freeways. These would have allowed minor incidents, such as disabled vehicles, to be removed more rapidly than actually occurred. Moreover, this is an inexpensive item relative to the magnitude of the service it would provide. (See Chapter 5 for a discussion of the push bumper option and Chapter 6 for an indication of the potential for using push bumpers.)

One incident which strongly indicates the utility of push bumpers occurred where a stalled vehicle in the center lane of a three lane roadway remained for almost an hour until a wrecker arrived (incident number 5). The incident occurred at dusk during off-peak traffic just beyond a crest vertical curve. The police officer protecting the scene was in an extremely hazardous position which could have been quickly solved had his vehicle been equipped with a push bumper.

Methods should also be sought which make equipment more accessible for incident management. This could mean purchasing additional equipment, moving maintenance depots closer to freeway locations, or keeping

close track of where each vehicle is located and how to contact the operator. Greater assurance could be gained that the equipment would be readily available if the service was restricted to incident use alone. Unfortunately, this would not be a cost-effective use of resources.

Interagency Cooperation

The two areas that will be briefly discussed here include cooperation in the provision of materials and personnel by the various agencies and the clarification of on-site responsibilities among the agencies present.

Provision of Materials

This topic has already been discussed to some extent and this discussion will not be repeated in detail here. General comments are offered below.

One relevant observation from the incidents is that there seems to be no hesitation by any agency to become involved in the incident through provision of materials and manpower to perform the required tasks. Although the intentions of the agency providing services generally were good, the services rendered were often inadequate. Typically, personnel at the higher levels of the highway departments were not hesitant about becoming involved but had great difficulty in fulfilling the requests which had been made. This could have been partially due to the lack of awareness of the severity of the problem or to lack of communiction from the higher ranks to the lower levels. These are problems which must be addressed in the future.

Countermeasures for this category are mentioned in Chapter 5, page 92.

Cognizance of On-Site Responsibilities

At all incidents questions arise as to who is responsible for supervising activities and who is responsible for decisions that must be made. Several of the problems which surfaced from the incident observations are discussed below.

At several incidents one particular police agency (e.g., local) initially responded to an incident and then turned the incident over to another police agency (e.g., state) when it arrived. This was sometimes found to delay incident clearance as it appeared that the first agency either did not have, or did not choose to exercise, the authority to clear

the incident.

There were more problems with the mutual understanding of roles between different agency types (e.g., police and fire). For example, at one observed incident a call for a private tanker to defuel an involved tanker was cancelled by another individual because he believed it to be no longer necessary. This demonstrates the importance of establishing clear, on-site responsibility so that any differences in judgement will not result in delays in decision-making. Multiagency input is very valuable, but quick decisive action is foremost in the incident clearance.

The only way in which this problem can be solved is by greater communication among various agencies prior to the occurrence of an incident. This may require periodic interagency meetings to resolve any differences and to establish definite criteria as to specific responsibilities under various conditions. Various circumstances which may arise if an incident occurs near a jurisdictional boundary should also be discussed and definite methods of allocating responsibility in these cases must be resolved. These elements are addressed in more detail in Chapter 5, page 88.

SUMMARY

The conclusions drawn from the incident observations have been summarized in a subjective manner in the two tables presented below. Table 3 is based on the categories of problems specified in this chapter and rates the problems on three important aspects. The first aspect is the estimation of the general proportion of incidents for which there is a problem in that category. No numerical estimates are used, only the general ratings of: "Low", "Medium", and "High". These signify the approximate proportion of incidents for which such problems could occur. For example, while diversion is a problem, there are only a limited number of incidents where diversion could have been implemented. The next important aspect is the impact of the problems on traffic delay and safety at individual incidents. For instance, one problem might exist for a low percentage of incidents but may introduce significant increase in delay and reduction in safety when it does occur. The third measure is the potential for rectifying the problem. An attempt has been made here to assess this potential based on technical and/or administrative feasibility and as indicated from the study of these 30 incidents.

Table 4 is similar to Table 3 but differs in that specific countermeasures are rated for the percent of incidents they could improve, potential benefits at individual incidents, and their potential for implementation.. In this case the range of applicability of the countermeasures is based on

TABLE 3

SUMMARY OF INCIDENT PROBLEMS

PROBLEM CATEGORY	ESTIMATED PROPORTION OF INCIDENTS AT WHICH PROBLEM EXISTS			IMPACT OF THE PROBLEM ON DELAY AND SAFETY			POTENTIAL FOR IMPROVEMENT *		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Supervision of On-Site Activities									
Needs Assessment	X				X		X		
Setting Priorities	X				X				X
Arranging for Services	X					X		X	
Traffic Control and Driver Information Techniques									
Use of Vehicles at Incident Site	X			X			X		
Use of Flares, Cones, Etc.		X			X			X	
Manual Merging Techniques	X				X		X		
Advance Warning for Motorists			X			X	X		
Determining Extent and Means of Lane Closure	X			X			X		
Forecasting Impact of Incident on Traffic Flow		X			X		X		
Implementing Diversion Procedures		X				X			X
Providing Information Through Media		X			X			X	
Equipment and Manpower Requirements									
Availability of Emergency Services	X				X		X		
Availability of Traffic Control Devices			X			X		X	
Availability of Site Clearance Equipment			X			X			X
Interagency Cooperation									
Provision of Materials		X			X		X		
Cognizance of On-Site Responsibilities	X			X				X	

*Described in previous sections.

TABLE 4

POTENTIAL EFFECTIVENESS OF TRAFFIC CONTROL PROBLEM COUNTERMEASURES

INCIDENT PROBLEM COUNTERMEASURE	ESTIMATED PROPORTION OF INCIDENTS AFFECTED			POTENTIAL BENEFIT AT INDIVIDUAL INCIDENTS			POTENTIAL FOR IMPLEMENTATION		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Improved Training in Traffic Control			X		X			X	
Off-Freeway Investigation Policy		X				X			X
More Comprehensive Phone Lists	X				X				X
Maintaining Inventory of Personnel and Equipment Locations	X					X	X		
Advance Warning System—Signs On Vehicles Upstream			X			X			
Advance Warning System—Signs On Vehicles On-Site Only			X		X				X
Advance Warning System—Fixed Changeable Mess. Signs			X			X	X		
Traffic Impact Forecasting Procedures		X			X			X	
Diversion Preplanning—Route Selection Only	X			X					X
Diversion Preplanning—Overall Mobilization	X					X	X		
Improved Information Link With Media	X				X			X	
Stockpiling Traffic Control Devices Along Freeway	X				X		X		
Provision of Push Bumpers On Police Vehicles			X			X			X
On-Site Reference Materials		X		X				X	
Establishment of Command Posts	X				X				X

the total incident population and reflects the frequency of various types of incidents (see Chapter 6).

In the final project documents it is anticipated that this material will be expanded to reflect the actual percentages of the total number of incidents that occur within the respective categories. This would in effect provide a means for assessing the relative merits of the remedial actions and provide a basis for cost-effective analysis with respect to affecting the total number of incidents that occur. It must be stressed that these summary tables are general in nature and are based upon the observation of a fairly limited sample of incidents, although they have been supplemented with other historical data (see Chapter 6). The degree of the problem varies throughout the country. The attempt here has been to depict the most prominent problems. Areas which should receive the greatest amount of attention in the future, whether they be problems or countermeasures, are signified by the highest ratings.

CHAPTER 5

ADMINISTRATIVE; ORGANIZATIONAL AND PREPLANNING OPTIONS

INTRODUCTION

This chapter discusses the administrative, organizational, and preplanning options that are currently being used by agencies and groups involved in freeway incident management. With few exceptions, these options require little or no capital expenditure, for they are primarily the result of off-site, pre-incident, management decisions affecting an organization's allocation of existing resources, its effective mandate, its relationships with other groups in the incident management system, and its degree of preparedness to perform its duties when an incident occurs. The high cost-effectiveness of these options should make them attractive to organizations interested in designing a minimum investment system.

Administrative options are intra-agency activities intended to improve an agency's ability to fulfill its present incident management role, or to expand that role to include new responsibilities. Options such as encouraging coordination among existing groups within the agency and establishing a new or modified group to specialize in incident management are examples of the former type. The latter, role-expanding options include executive decisions and policy declarations, as well as legislative efforts aimed at specific laws and ordinances.

Organizational options, involving inter-agency coordination, seek to facilitate the expeditious, cooperative effort that characterizes a successful incident management system. This is accomplished by establishing relationships among FIM agencies and organizations, clarifying each participant's role and responsibilities, and maintaining open channels of communication for immediate incident coordination and subsequent reconciliation of problems encountered during the incidents. Typical relationships include those among agencies with complementary authority (such as police), those between police and highway agencies, those with other public agencies (such as fire and emergency medical services), and those with the private sector. In addition, relationships can be developed with private citizens and citizen organizations interested in incident management.

Preplanning options are designed to prepare an agency and its personnel for the eventuality of an incident requiring their resources. While experience is often the best preparation because of the individual nature of incidents, certain techniques and knowledge are basic to most incidents.

Furthermore, a particular agency usually performs the same general tasks at any incident, regardless of the situation's particular circumstances. In light of these facts, it becomes incumbent upon the agency to develop materials that anticipate its duties and that enable its personnel to perform them efficiently. Examples of these preplanning options are the development of standard operating procedures, training programs and materials, and reference materials to be used at the central communications facility or deployed in the field.

The format for discussing specific examples of administrative, organizational, and preplanning options is as follows. First, the individual option is defined, and its scope and spectrum delimited. Options range from loosely to highly institutionalized arrangements and from low-level operating practices to high-level policy agreements. Next, the option's general issues, common to all sponsoring organizations, are considered. These include such aspects as costs, both in terms of dollars and level of organizational impact; level of administrative responsibility involved; coordination required; communications necessary; degree of simplicity or complexity; and measurement of effectiveness. Third, option issues specific to particular organizations sponsoring the FIM activity are discussed. These organizations are the same as those described in Chapter 2. Finally, a general assessment is made of the option and its contribution to a minimum investment incident management system. This is based on the literature, the opinions of persons interviewed, and the conclusions of the PMM&Co. staff.

Each of the options is discussed following the format given above. Specific topics are introduced only insofar as observations were made from the interviews and literature reviewed.

ADMINISTRATIVE OPTIONS

During the literature review, site visits, and telephone interviews, five administrative options were encountered: a dedicated freeway unit, placement of response vehicles, accident investigation sites, a fast vehicle removal policy and a flashing lights policy.

Dedicated Freeway Units

Dedicated freeway units are vehicles and personnel assigned to a freeway in either a full or part-time detection and/or response capacity. They are usually operated by law enforcement agencies, although service patrols sponsored by highway departments, volunteer citizens groups, and private companies also exist. Their purpose varies (depending on the operating organization) from traffic law enforcement to disabled motorist assistance. Generally, police departments stress the enforcement purpose while other agencies or groups concentrate on providing breakdown and information services. The extent of police involvement in these service activities varies widely and is discussed below. Another type of dedicated freeway unit is used by one state DOT to monitor traffic upstream of an incident, and to implement alternative routes as required to relieve congestion (252). While this incident response unit provides a "service" to motorists, it is unique, and not to be confused with the more prevalent service patrol.

Police Freeway Patrol

The most common type of dedicated freeway units are police freeway patrols. Operated by either the state or local police, these units are usually composed of vehicles that are specially outfitted for freeway operations. Ordinary patrol cars are most frequently used, although they may be augmented by station wagons or motorcycles. Their special equipment ranges from removal devices (e.g., loudspeakers, pushbumpers, and towstraps) to warning devices (e.g., cones, variable message signs, and highriser lighted arrows) to service features (e.g., jumper cables, water, gas transferral devices, air tanks, and tool boxes) to information handouts (e.g., maps and ferry schedules).

The degree to which a police freeway unit provides motorist services depends on department policy, and in turn on the equipment available to a patrolman. Most agencies assume a passive role with regard to disabled vehicles, and merely require their officers to radio for a private towtruck. Some take a more active role and encourage their patrol units to push vehicles off the traveled portion of the roadway to the shoulder or the next off-ramp. Fewer still empower their officers to provide gas and water to breakdowns. Even rarer is the department that equips its men to make minor engine repairs on the freeway.

Police freeway patrol hours of operations vary as a function of fleet size and the degree of service specialization. Standard vehicles, perhaps equipped with the minimum piece of freeway equipment, a pushbumper, operate 24 hours a day. More specialized vehicles tend to be fewer in number and operate fewer hours each day. In some cities these units patrol only during the peak periods. One police department interviewed operates a service station wagon for 16 hours a day, but this is an exceptional case.

Other Service Patrols

Dedicated freeway units operated by highway departments, citizens groups, and private companies are (with the exception of the DOT incident response unit mentioned above) totally service oriented. Their vehicles are typically 3/4-ton pickup trucks or large vans outfitted with equipment designed to meet a variety of motorist needs. Supplying gas, water, and air, changing flat tires, extinguishing small fires, and distributing maps and information are the basic services provided by these units. In addition, some courtesy patrols perform minor mechanical work and offer such comforts as coffee, blankets, and ditty bags. Highway department service patrols usually have the additional responsibility of keeping the roadway clear of minor debris.

Surprisingly, most service patrols are not equipped to push or pull disabled vehicles. The sponsoring organizations tend to avoid having this capability for fear of incurring damage liability and troopers may be reluctant to use this capability if they have to pay for damages to their own vehicles. Many that do have it require the motorist to sign a release before they will use their pushbumpers. On the other hand, one city traffic department that was interviewed has a policy of pushing disabled vehicles off the road, but will not supply any other assistance thereafter "since that might encourage motorists to rely on it." (119) A similar fear expressed by some highway departments is that the provision of gas, water, and minor repair work constitutes unfair competition with private service stations. The single private, non-citizen service patrol encountered by PMM&Co. is operated free-of-charge by an automobile dealership for "public service" reasons (39).

Freeway units operated by organizations other than police agencies are usually small and have limited hours of operation. Patrols with one or two vehicles operating during the morning and evening peak hours are common. An exception is the volunteer, citizen-operated courtesy patrol contacted by PMM&Co. that operates only on weekends and holidays, but does so 24 hours a day(203). Patrol frequency for freeway service patrols

is low too, since a vehicle must cover a substantial freeway mileage. Longestablished service patrols tend to be larger in size and have greater frequency. For example, one 13-year-old program, despite inevitable cutbacks, still operates ten vehicles 24 hours a day(182).

Issues Common to All Organizations

Cost. Cost is the major issue for organizations considering the operation of a dedicated freeway unit. If a unit is to be formed from existing vehicles and manpower, then costs may be limited to expenditures for specialized equipment or overtime wages. However, if a unit is created requiring new vehicles and personnel, then costs are significant, and in many cases, prohibitive. One police department interviewed by PMM&Co. purchased the following vehicles and equipment for their freeway patrol in November 1974: (23)

1. Four (4) cars @ $4,500 each	$ 18,000
2. Four (4) radios @ $1,382 each	5,528
3. Four (4) electronic sirens @ $325 each	1,300
4. Four (4) twinsonic light bars and speakers @ $425 each	1,700
5. Four (4) radar units @ $2,100 each	8,400
6. Four (4) Vu-control bars @ $850 each	3,400
7. Four (4) sets of pushbumpers @ $80 each	320
Total Cost	$ 38,648
	or $ 9,662 per vehicle

Even after taking drivers from the existing force and receiving a matching grant, this department incurred a capital cost of $19,724. Additionally, a $1,680 annual operating cost is estimated for their vehicles.

Appendix B presents total operating costs (vehicle and labor) for a variety of freeway dedicated units. Operating costs depend greatly on the patrol's hours of operation, which in turn have an effect on labor costs. Patrols of-offering eight or more hours of daily service can hire full-time personnel at

prevailing wage rates of commercial vehicle drivers and semiskilled mechanics. In contrast, patrols that operate for fewer than eight hours daily (generally running only during four peak period hours) are often forced to pay overtime wages or shift splitting fees to existing department employees. Frequently, these are professional engineers who command significant hourly wages and whose overtime wages are consequently high.

In the case of one rush hour service patrol observed, over 70 percent of the total FY75 cost was for the wages of the two operators. But even if labor costs are avoided by using citizen volunteers, operating costs are not negligible. The weekend and holiday citizen patrol contacted by PMM&Co. spent $330 for gas and oil during the 1975 Christmas-New Year's ten-day holiday period. Furthermore, the commander of the patrol has personally invested $19,000 in securing three vehicles and the entire patrol's communication equipment.

Another issue common to organizations operating dedicated freeway units is the administrative cost associated with the patrol. The amount of manpower necessary to supervise a unit is directly related to the size and responsibilities of that unit. These range from an entire state police troop assigned to a tollway with complete enforcement and service responsibilities to a single highway department service vehicle patrolling a section of urban freeway during peak periods. In the former case, the administrative framework includes sergeants and lieutenants who oversee the day-to-day operations, and captains and majors who administrate the troop as a whole. In the latter case, only a district maintenance engineer and a camp superintendent are necessary for supervision. Supervision of service patrols is usually a part-time activity for which no cost figures are available. Only one patrol interviewed employs a supervisor who devotes all of his time to the service patrol.

Level of Responsibility. The level of assumed responsibility is another issue common to organizations sponsoring dedicated freeway units. This is determined in part by the organization's established obligations and in part by its policy regarding the provision of motorist aid. For example, police units are duty-bound to protect incident sites and to warn on-coming traffic of potential hazards. But the extent to which they render aid to disabled motorists is usually a police decision made within the department itself. Similarly, highway maintenance divisions are responsible for repairing damage to the facility and for keeping the right-of-way free of debris. Service patrols are generally established outside of the department's mandatory responsibilities of freeway design, construction, and maintenance.

Once a policy of rendering service has been established by a police agency or highway department, the level of assumed responsibility becomes a function of the level of service provided. The more assistance a service patrol is willing to offer, the more obligation and liability it is likely to incur. This relationship is particularly apparent with regard to the use of pushbumpers and towstraps in removing disabled vehicles from the travelled way. Many organizations refuse to equip their patrol vehicles with this capability for fear of being sued for negligence or damages. This feeling is particularly prevalent among policemen, who usually prefer to summgn a wrecker for this purpose. Some more service-minded organizations secure a signed release statement from the disabled motorist before pushing his vehicle to the shoulder or down the nearest exit ramp. Others take an even more active role in vehicle removal by pushing first and worrying about liability later. The use of pushbumpers and towstraps will be discussed at greater length in the section dealing with the administrative option of fast vehicle removal.

Communications Necessary. The communications equipment necessary for operating a dedicated freeway unit usually exists already within the sponsoring organization prior to the formation of a specialized unit. Established police and highway department radio frequencies can adequately handle the transmissions of a new unit. To improve service, however, some service patrols have been equipped with an exclusive radio frequency or an additional police or highway department radio, depending on which agency is its sponsor. Patrol vehicles with this dual communications capability can reduce response time by receiving a direct message from a police or maintenance unit, rather than one passed from dispatcher to dispatcher. Another communications consideration is the potential use of Citizens Band Radio in freeway patrols. For citizen-operated organizations, CB radio is a virtual necessity, particularly as a detection device. Chapter 3 has a comprehensive discussion of CB radio and incident management, so no attempt will be made here to delineate the issues.

Degree of Simplicity or Complexity. The operation of a freeway dedicated unit is a relatively simple administrative task. Once created, a patrol tends to have a highly institutionalized nature. Well defined schedules, beats, and operating procedures are characteristics of all those sponsored by public agencies, as well as those run by the citizen's group and the private company interviewed by PMM&Co. It is in the development stages that difficulties may be encountered. The initial decisions regarding the required manpower and equipment, the hours of operation, and the level of services to be offered must be made within the context of the existing agency's budget and its current responsibilities. Some of the proposed unit's services may involve tasks that agency employees have

never had to perform and do not want to perform. This problem is particularly characteristic of police departments, where traffice enforcement is frequently considered to be less interesting than criminal enforcement, and providing motorist assistance is considered unexciting. The problem is whether the agency perceives its role as one of law enforcement or and service to motorists.

Organizational Specific Issues

State Police/Highway Patrol. Like many public agencies throughout the country, state police and highway patrol departments have suffered from recent budget and manpower cutbacks. A necessary way to counteract these circumstances is to reduce freeway patrol frequency and coverage, thereby stretching available resources. This strategy is particularly applicable to areas in which another police force is available for enforcement. Thus, although state police often have primary, if not sole, jurisdiction on interstate highways within incorporated areas, they may decrease (or even terminate) patrol frequency in these areas, assuming that local municipal and county police departments will take up the slack. From the highway patrol's perspective, this is the most logical adjustment to combat manpower shortages. This attitude has resulted, however, in at least one major metropolitan area having an almost complete lack of traffic enforcement on its interstate system. The real issue here is the state police's responsibility to ensure that a freeway patrol is maintained by local departments in the event of a cutback in the state police freeway patrol.

Local Police. Another issue, involving dedicated freeway units, confronts many local police departments. The trend toward "team policing," that is, the division of a city into individual beats within which a policeman is responsible for all law enforcement (i.e., criminal, traffic, etc.), deemphasizes the duties of specialized traffic divisions including freeway units. The team policing concept has been implemented in many cities as a deterrent to individual and property crimes. The beat policeman with part of a freeway running through his beat will not be able to devote considerable time to traffic enforcement or incident detection. In a departmental reorganization to implement team policing, traffic enforcement is sometimes eliminated as a specialized unit and is deemphasized as the responsibility of the individual patrolman.

Transportation and Highway Departments. A concern of some transportation and highway departments regarding service patrols is the extent to which they compete with existing private service stations. This concern is raised primarily in the consideration of whether or not to tow disabled vehicles. Dispensing gas, water, and oil, supplying maps and information, and performing minor engine repairs are tasks that usually go unchallenged

either by highway engineers or private service station operators. Towing, perhaps because it is a lucrative business, seems to be a more sensitive issue. Despite that fact, PMM&Co. knows of no direct confrontation between a highway department and service station operators over towing. At the same time, however, no known DOTs or highway departments will tow a vehicle beyond the exit ramp of a highway.

Citizen Groups. Cost is an issue for all sponsoring organizations (see Issues Common to All Organizations, above), but is particularly significant for citizen groups. Lacking any continuing source of funds, citizen groups must rely on private donations and their own personal savings to finance a dedicated freeway unit. They can try to secure some basic equipment (e.g., flares, first-aid kits, etc.) from local or state governments, but these efforts may not be successful. Donations from assisted motorists are welcome but generally not solicited. Like many non-profit citizen organizations, a safety patrol must constantly use its imagination to tap existing sources of financial support and uncover new ones.

Assessment

For those organizations that can afford it, a dedicated freeway unit is a very effective incident management option. Not only can it reduce detection time, but equipped with minimum service capability, it can also respond to minor breakdowns and stops. This is an important consideration because so many unscheduled stops are due to running out of fuel, overheated engines, information needs, and minor mechanical failures, all of which can be serviced by an adequately equipped vehicle with a properly trained driver. In addition, such a unit can perform some of the tasks traditionally performed exclusively by law enforcement units. These include warning oncoming traffic of an accident ahead and protecting the incident site. Obviously, the performance of many of these activities is dependent on having some specialized equipment. Indeed, it would seem to be a waste of resources to have a freeway patrol that could not at least, in the case of a police agency, push a disabled vehicle off the roadway, or in the case of a highway department or citizens group, provide enough services for the vehicle to get to a service station for major repair.

The decision to equip vehicles with pushbumpers despite potential liability problems appears to be a worthwhile gamble. The organizations that have this capability do not worry about the consequences; those that do not have it appear to have groundless fears of liability. Rarely is legal counsel sought to settle the issue, for to many agencies, particularly police, the use of pushbumpers to clear the roadway is a logical extension of the police's responsibility in protecting the public.

None of the other issues discussed diminish the basic value of dedicated freeway units. Unfortunately, police departments with serious manpower shortages or a team-policing organizational structure will not even consider forming a freeway unit. Competition with service stations is not a serious problem either, because it is an issue only when an agency considers the range of services to be provided, not whether a basic service should be instituted.

Another aspect of freeway units to be kept in mind is the public reaction to them, which in every case has been predominantly enthusiastic. The literature is full of comments from grateful motorists. This public relations benefit of operating a dedicated freeway unit should not be overlooked by the organization considering one.

Placement of Response Vehicles

This administrative option involves the positioning of response vehicles at selected points, other than at the vehicles' normal dispatching base, on a freeway or point facility. A variation of this procedure is the repositioning of response vehicles to maintain uniform coverage when a single vehicle or squad is dispatched. Depending on historical incident circumstances, these vehicles may be police cars, wreckers, ambulances, fire engines, or any other vehicle type that may be necessary to handle an incident. This option's purpose is to decrease response time, particularly to high incident locations and places, such as tunnels and bridges, where even a minor incident has a serious impact on traffic flow. This technique ranges from rush hour placement to computer-determined variable positioning.

The placement of response vehicles option usually originates within the planning staff of the sponsoring agency. Through an analysis of incident data, a planner may determine a more satisfactory dispatching location for a particular response vehicle (30). Once this placement is implemented, the option becomes a simple operating practice of moving the vehicle to its assigned location at a prescribed time, and returning it to its home base afterwards. Or the vehicle may be stationed permanently near a high incident location. Permanent stationing is considered to be an example of the placement of response vehicle option as well, for the vehicle's maintenance and refueling facilities are likely to be located somewhere else.

Two examples of the use of this option were discovered by PMM&Co. in the course of the field interviews. One is the assignment of one highway department wrecker at each end of a floating bridge (70). From these vantage points, the operators are able, with the aid of binoculars, to detect incidents and respond immediately. In a natural bottleneck situation such as this, the ability to respond immediately with a wrecker significantly reduces

the impact an incident may have on traffic flow. The other example of response vehicle placement was encountered within the municipal fire department of a large city (243). A computer-aided dispatching system repositions fire equipment if, due to a former commitment of an engine company, uniform coverage is lost. Although this is not a freeway-specific system, it could be designed for vehicles responding to freeway incidents only. Furthermore, it does not have to be computer-dependent. A simpler readjustment of resources can be made without using a computer.

Issues Common to All Organizations

Cost. Cost is the only important common issue concerning response vehicle placement, but it has several aspects. First, there is the question of whether or not it is cost-effective to commit vehicles to specific locations when there may be a need for them elsewhere too. Next, in the case of the repositioning technique, a considerable expense may be incurred in terms of fuel and maintenance. Although an individual vehicle may be displaced only a short distance at any one time, the aggregate cost of moving all of the system's vehicles many times will be significant. Finally, there are the normal acquisition and operating costs that an organization faces regardless of the way the vehicle is dispatched.

Since this option assumes that a response vehicle is already available, the last cost issue mentioned above is essentially irrelevant. Once a response vehicle is available for special placement, the central question becomes whether or not that placement can be justified. Careful analysis of incident frequency, location, severity, and effect on traffic is the only way this question can be answered. It must be shown that the vehicle located on a freeway or near a bridge can be expected to respond to a sufficiently high number of incidents and to alleviate a considerable amount of congestion in order to justify its special placement.

Organizational Specific Issues

Point Facility Operators. The question of whether or not to implement a form of the response vehicle placement option has particular significance for the operator of a point facility. The operator usually has no choice but to station response vehicles nearby, for even a minor breakdown has the potential to force the closing of part of the facility. The fact that such a closing would have a noticeable effect on toll revenue is an important consideration too.

Assessment

The placement of response vehicles near point facilities having restricted geometrics is essential if traffic flow is to be quickly restored after an incident. On urban freeways, it is not as effective a strategy unless there are particular locations with extremely high incident histories. Repositioning procedures are more applicable to agencies having a large fleet of emergency vehicles (e.g., fire departments and ambulance companies) than they are to police departments or wrecker companies. And, given that fire departments and ambulances respond to only a very small percentage of freeway incidents (see Chapter 6), it is unlikely that such a technique would impact on freeway incident management.

Accident Investigation Sites

Accident investigation sites are designated areas located off of urban freeways where law enforcement officers can investigate accidents without creating secondary accident hazards or encouraging the formation of gaper's blocks (170). Ideally, they are situated out-of-sight of passing motorists, but at least, they must be well out of the traveled portion of the freeway. Often they are located on an exit ramp or under an overpass. Their placement ranges from designated areas on ramps near high incident locations to areas on every exit ramp. They may consist of simple signs indicating unpaved areas, or of paved areas complete with lighting and emergency telephones. Their purpose is to encourage police officers to conduct their accident investigations at sites off of the freeway, thus reducing an accident's impact on traffic flow. Additionally, they are meant to encourage motorists to drive off of the freeway when they have had a minor accident, instead of waiting for a police officer to tell them to do so.

Only one police department contacted by PMM&Co. is known to have accident investigation sites at this time. A number of departments expressed interest in the idea, and at least two are actively planning for them. The single existing example consists of "Accident Investigation Site" signs furnished and installed by the state DOT on lightposts along selected exit ramps. Presently, the sites are unpaved portions of the freeway's shoulder, but the DOT has promised to pave them if warranted. One of the police departments planning for accident investigation sites proposes to erect signs, pave eight selected areas, provide lighting, and mount a comprehensive publicity campaign to inform the public. Emergency telephones linked to police headquarters are also being considered for these sites.

The impetus for the creation of accident investigation sites must originate at the executive level, since it signals a major policy change for the law enforcement agency. Once established, however, the use of the sites becomes a low-level standard operating pratice.

Issues Common to All Organizations

Level of Responsibility Involved. In sponsoring accident investigation sites, a police agency takes on the responsibility for ensuring that these areas are properly used. Not only should it insist that its officers use them whenever possible, but also it should try to secure public participation and combat potential abuses of the sites. Getting an accident victim to move his vehicle to the nearest accident investigation site before an officer arrives will require sufficient publicity to overcome popular misconceptions about insurance regulations. This particular issue will be discussed at greater length in the section dealing with the fast vehicle removal option. Potential abuses of the sites include unauthorized parking and the stripping down of damaged vehicles left there. Also, a tradeoff exists between site security and site visibility. The more visible a site is to passing motorists, the more secure it will be. At the same time, however, the more potential it will have for causing gaper's blocks. This tradeoff and other problems should be kept in mind by any agency considering accident investigation sites.

Assessment

The use of accident investigation sites can be a very effective method of minimizing traffic congestion and gaper's blocks after an accident has occurred. Essentially a policy improvement, it is easily implemented by executive order and requires only a small capital expenditure for signs and possibly paving. A substantial publicity campaign is necessary, however, if officials want motorists to proceed to the sites on their own initiative. The potential problems attendant to this option are not insurmountable either. Parking violators can be dealt with as department policy dictates, and the threat of car-stripping can be minimized by adequate patrolling.

Fast Vehicle Removal

The fast vehicle removal administrative option involves one or more of three ways to ensure that disabled, abandoned, or damaged vehicles do not constitute hazards to other motorists. First, a legislative effort would require motorists to move their vehicles (if possible) off of the roadway immediately after an accident. This includes legal decisions that declare vehicles with flat tires to be driveable and not disabled. The outcome of this effort may take the form of a municipal ordinance or state law. Second

would be the establishment of a maximum time limit for leaving vehicles in nonhazardous locations within the freeway right-of-way. The motorist is given a certain amount of time to arrange for the vehicle's removal. After this time has elapsed, the vehicle is towed away by the police at the owner's expense. This version of the fast vehicle removal option may be an ordinance or law, but it also may be simply a policy decision made by the police department. Finally, fast vehicle removal may take the form of police or DOT operating procedures to remove disabled vehicles immediately using pushbumper-equipped vehicles or towtrucks. This is an operating procedure that usually originates as a policy decision made at the executive level. However, legislation enacted to absolve these agencies and their employees of any liability associated with vehicle removal may be necessary.

The spectrum of this option varies as the number of sub-options implemented and as the time limit established in the second sub-option for removing a nonhazardous disabled vehicle. Few cities have all three variations implemented. Laws requiring immediate removal by motorists of disabled but driveable vehicles are rare. Cities with pushbumper-equipped police or highway department vehicles are more common, but not widespread. On the other hand, police departments with policies setting time limits for abandoned vehicles on the freeway are numerous. This time limit ranges from 2 to 24 hours depending on local circumstances, and may vary by urban versus suburban or rural conditions. Most police departments require immediate removal of disabled or abandoned vehicles that constitute hazards to oncoming traffic.

Issues Common to All Organizations

Cost. Costs in dollar terms of implementing a fast vehicle removal policy are almost negligible, and in administrative terms are variable, depending as they do on the required legislative effort. The sole piece of equipment associated with this option is the pushbumper, which, as noted in the section on dedicated freeway units, costs approximately $80. Costs for towing and storing abandoned vehicles are recovered from the owner or by resale. Administrative costs are directly related to the amount of time that must be spent on the new policy proposal. The collection of data, preparation of testimony, and other general lobbying activities may be required before a fast vehicle policy can even be implemented.

Level of Responsibility Involved. The key issue involving the fast vehicle removal option is the law enforcement agency's or DOT's current policy regarding the use of pushbumpers. If they are presently in use, then the agency has either prepared itself for possible legal action, rejected the possibility of incurring liability, or simply ignored the issue altogether. For the agency

considering the adoption of pushbumpers, however, none of these strategies may be attractive. The remaining alternative is to lobby for legal protection under a municipal ordinance or state law. Pennsylvania state law projects all law enforcement and department of transportation personnel from any liability for damage incurred to vehicles or cargo in the process of incident cleanup. The enactment of such a law would allay the fears that many law enforcement agencies currently have about pushing disabled vehicles. Significantly, the International Association of Chiefs of Police supports the limited use of pushbumpers on controlled access highways (191). The association recommends that every patrol vehicle be outfitted with a pushbumper, and that it be used for removing abandoned, stalled, and damaged vehicles from traffic lanes.

Communications Necessary. As mentioned in the discussion of accident investigation sites, agencies hopeful of developing public initiative in moving vehicles out of the roadway after an accident face a substantial problem. Popular belief has it that the vehicles involved in an accident, however minor, should not be moved from their post-accident positions until a police officer arrives at the scene. It is widely believed that to do otherwise would jeopardize insurance claims and the investigation of the accident. Throughout the telephone and field interviews, however, PMM&Co. failed to find any justification for this belief. In fact, insurance companies generally endorse immediate vehicle removal since it minimizes the potential for secondary accidents and additional claims. Similarly, police agencies advocate immediate citizen removal of the vehicles wherever possible because this is usually the first action they take at the site themselves. But even in the face of these positions, the popular misconception regarding vehicle removal often prevails. Only a determined, comprehensive publicity campaign can be expected to alter this belief.

Assessment

A fast vehicle removal policy, particularly one allowing properly equipped police or DOT vehicles to push disabled vehicles off the roadway, is an effective, inexpensive way to minimize secondary accidents and traffic congestion. Laws requiring citizen initiative are less noteworthy due to the significant publicity campaigns that must be mounted to make them effective. Besides, many disabled vehicles are often unable to proceed under their own power (see Chapter 6). A maximum time limit for leaving a vehicle unattended on the freeway is less effective in terms of incident management, but is still a sensible policy to adopt, which has been adopted by eighteen states.

For organizations fearful of incurring liability in active vehicle removal, the best course to take is to lobby for legislation protecting them from civil suits. Then they can assume a more active role in fast vehicle removal as well as other aspects of incident management.

Flashing Lights Policy

A flashing lights policy is an effort to reduce an emergency vehicle's natural tendency, by its mere presence, to cause a general traffic slowdown and encourage the formation of gaper's blocks. It is aimed at eliminating the indiscriminate use of flashing lights, especially rooftop-mounted ones, that frequently create flow problems without serving any useful purpose. This policy does not apply to situations in which a hazard exists and a slowdown is desirable. This administrative option is applicable to any emergency vehicle, but particularly to police cars and ambulances whose red flashing lights draw the most attention from passing motorists. Initially, it is a policy decision made at the executive level, but it soon becomes a low-level operating practice.

Many departments recognize the potentially adverse effects of flashing lights and have established policies governing their use. Only one department, however, is known to be attempting to evaluate the impact of this option (7). This highway patrol has had some of its cars' roof-mounted "Visibar" lights removed to determine if traffic slowdown and gaper's block problems can be lessened. For stopping violators, these lights have been replaced by flashing red lights mounted in the high-beam headlight position in the front grill. Amber or red deck lights are used for warning purposes in the absence of the dome lights.

Issues Common to All Organizations

Measurement of Effectiveness. The only issue concerning a flashing lights policy is whether or not it achieves its stated goal without sacrificing safety. This is, unfortunately, a very difficult determination to make. The highway patrol experiment mentioned above consists of the collection and analysis of beat patrolmen's opinions regarding the effect of the policy on traffic flow. Results of this experiment are not yet available.

Assessment

Intuitively, the implementation of a flashing lights policy would seem to have a beneficial effect on traffic flow without compromising safety. This preliminary assessment is based on the assumption that all of the essential roof-mounted lights remain in operation or are adequately replaced by other lights. More research is necessary, however, before a definitive position can be taken.

ORGANIZATIONAL OPTIONS

As a result of the literature review, site visits, and telephone interviews, PMM&Co. has formulated the following organizational options: a police/highway department relationship; relationships with other public agencies; ties with local transit authorities; a citizen group liaison; wrecker contracts; private sector services coordination; media ties; and a freeway telephone trouble number.

Police/Highway Department Relationship

Some type of relationship exists between any police agency and the municipal or state highway department responsible for maintaining the roads on which the police agency operates. At the very least, this relationship consists of communication between patrolmen and maintenance personnel concerning highway repairs, major construction activities, and, in many regions, snow removal efforts. The organizational option to be discussed here goes beyond this basic relationship and involves each agency's responsibilities for incident management. Certainly, this subject is discussed at the operations level as well, and, in some cases, no higher up in the organizational structure. But due to the potential overlapping of police agency and highway department incident management responsibilities, it deserves consideration at higher levels of management.

The option is defined as the working relationship between these two organizations with respect to incident management. This includes not only operational interaction such as on-site communications and cooperation, but also administrative relationships such as joint agreements and forums on problems of mutual concern. The wide range of this option depends on each organization's mandate, its traditional responsibilities, and its personnel. The perceived extent of the incident management problem in a particular area is also an important factor in determining the nature of a police/highway department relationship. Areas that have experienced numerous or serious incidents are likely to have a different inter-agency situation than areas in which no serious incidents have occurred. Given these factors, this option ranges from a day-to-day operational relationship concerned with the management and cleanup of individual incidents, to occasional administrative collaboration on specific projects and studies, to full-time cooperation and coordination of incident management activities at all levels. Regardless of the type of relationship or the organizational level at which it exists, the purpose of a police/ highway department relationship is the same: to facilitate an expeditious, cooperative effort in dealing with incidents when they occur.

In the course of the field and telephone interviews, PMM&Co. observed a variety of police/highway department relationships at different

organizational levels. All of them involve, at a minimum, communication and coordination at the operational level between highway department district maintenance or service personnel and police agency beat patrolmen or troopers. This relationship develops naturally over time as a consequence of working on the same portion of a freeway system. Occasionally, it is strengthened by having direct radio contact between vehicles, but most departments communicate by telephone through their respective dispatching centers. When an incident occurs, the police usually respond first, and the patrolman at the scene decides whether or not highway department personnel are needed. This decision is made according to the responsibilities and capabilities of the highway department as determined by general operational tradition or specific administrative policy. In most states, these duties include repairing damaged facilities, sanding liquid spills, transferring spilled cargo, and, when road damage is significant, erecting detour or cautionary signing.

The next type of policy/highway department relationship observed by PMM&Co. involves the collaboration of administrative and planning staffs on particular projects or studies of mutual concern. For example, one state's highway patrol and department of transportation coauthored a crash control and cleanup manual for use by both agencies (74). Similarly, a joint police/DOT effort is often required for the planning, installation, and operation of motorist aid systems; Chapter 3 discusses this particular example at length. A third example is one city's freeway corridor committee, which is composed of both the local and state traffic engineers as well as a local police captain (65). Finally, there is usually close cooperation and coordination between traffic engineers and police in cities with freeway surveillance and control projects. It should be noted that these are examples of cooperative efforts for a predetermined length of time or a specific project, and as such, do not represent permanent agencywide relationships.

The third observed type of police/highway department relationship is that brought about by the development of a joint operational policy statement. This step is often taken in the wake of a major incident that has had serious congestion effects and has exposed the shortcomings of existing operational procedures. It introduces to the relationship three new aspects: permanence, agencywide applicability, and, most importantly, clarification of each agency's responsibilities. This is accomplished by restating each agency's mandate and describing a joint standard operating procedure to be followed when an incident occurs. Responsibilities for particular incident management activities are assigned to either police or highway department personnel. Cooperation and coordination are stressed throughout these policy statements, and a provision is usually included for scheduled meetings between representatives of the two agencies to discuss incident management. These joint policy statements are coauthored by executive staff members of the two

departments and signed by each department's chief administrator to give them agencywide impact.

The final type of police/highway department interaction encountered by PMM&Co. is at the same time the most unique and the closest working relationship. It involves the permanent assignment of a state highway patrol officer to the freeway operations branch of the state's DOT. In this position this officer acts as a liaison between the two departments, coordinating their joint efforts on both individual projects and day-to-day operations. Furthermore, the officer conducts training programs designed to familiarize patrol officers with freeway traffic control techniques, incident management problems, and the availability of traffic flow information from the DOT's surveillence and control center. His efforts represent the highest degree of coordination observed by PMM&Co. during this study.

Issues Common to All Organizations

Level of Responsibility Involved. In attempting to structure a more cooperative relationship between the police and DOTs, traditional operating procedures have hampered progress. For example, police agencies are generally responsible for initial response and verification, protection of the incident site, assessment of required resources, traffic control and diversion, wrecker coordination, and accident investigation. As previously mentioned, highway department duties usually include repairing damaged facilities, sanding liquid spills, transferring spilled cargo, and erecting detour or cautionary signing when road damage is severe. In cities with sophisticated surveillance and control projects, however, the highway department/DOT role includes traffic management, and it is primarily in this area that an overlapping of interests may occur.

The basis for the conflict lies in each agency's perception of its own responsibilities and those of its counterpart. Police officers often consider themselves in charge of freeway operations, and this belief is reflected in a common police summation of each agency's mandate: "The highway department designs, builds, and maintains the freeways; we operate them." Another version of this philosophy states that the highway department is responsible for the stationary elements of the freeway environment, and the police agency for the mobile elements. On the other hand, highway department traffic engineers often consider freeway operations to be their responsibility. Many believe that most police officers do not have sufficient traffic operations training to assume the responsibility of maintaining maximum traffic volume during an incident, or planning the best route diversions.

Coupled with this conflict over traffic management is a disagreement over on-site authority. Police officials argue that the uniqueness of each incident demands that complete and final decision-making authority be vested in the ranking officer at the scene, and that all other personnel serve only in supporting or advisory roles. This reflects the general police philosophy that the individual policeman is responsible for making decisions in the field. In contrast, some highway engineers believe in the concept of remote incident management whereby the on-site manager consults with personnel at the dispatching or control center and collective decisions are reached. These engineers favor this method because of their experience with remote detection and surveillance. An early indication of the way that this issue may be resolved in the future was the redesignation of one state's electronic traffic surveillance and control center as a traffic "information" center. This name change parallels the state highway patrol's belief that the center should serve only as an information resource for officers in the field.

A compromise solution to the on-site authority debate is the implementation of a command post concept (183). When a major incident occurs, the first police patrolcar to arrive at the scene is designated as the command post. Here, the planning for managing the incident takes place. Any public ployee arriving at the scene is required to report directly to the command post. All communication with the dispatching center is conducted from there too. And, although final authority may still rest with the ranking police officer, highway department personnel will have had the chance to express their opinions in the command post forum.

Another issue affecting a police/highway relationship is the extent to which a police agency is familiar with and concerned about traffic congestion caused by incidents. Some departments concentrate on other aspects of incident management such as site protection and accident investigation. In the absence of established procedures for traffic direction or route diversion, motorists are left to find a way around the incident site without police assistance, or wait extended periods of time in traffic congestion.

Communications Necessary. A police/highway department relationship can only be as effective as the communications channels linking the two agencies. During regular working hours, this is not a problem. Police and highway department dispatching centers are usually linked by either direct or conventional telephone lines. Sometimes, highway maintenance and police patrol mobile units share a common radio frequency, but this is rare. After hours notification, however, is the greatest communications problem. Highway departments do not normally maintain 24 hour dispatching centers, so the police must have home telephone numbers for the district foremen and any other DOT personnel who must be contacted. One highway engineer

interviewed suggested the use of paging devices for off-hours notification (189). This would facilitate the prompt dispatch of highway department personnel, even when they were not at home.

Assessment

PMM&Co. views the development of a close police/highway department relationship as one of the most effective minimum investment options considered by this study. The opportunity to establish a close working relationship at all organizational levels is one that is always available and requires no capital or operating expenditures. Good, comprehensive planning, conducted in a cooperative atmosphere, goes far in improving each agency's ability to cope with major incidents. The issues mentioned above will be forced into the spotlight and hopefully resolved to the betterment of the general good. It should be obvious, however, that this will necessitate some compromise on the part of each agency.

Relationships with Other Public Agencies

This organizational option is defined as the development of working relationships between the agency with primary incident management responsibility (generally a police or highway department) and other public agencies or public-spirited organizations which perform specialized or backup incident management functions. These agencies include the standard emergency medical and fire companies as well as local and county law enforcement agencies that provide backup support. In addition, pre-incident interaction with environmental protection agencies, public utilities, and local automobile clubs will be considered here. These relationships range from documented mutual aid agreements to simple verbally agreed-upon standard operating procedures. Their purpose is to facilitate the dispatch of resources that are only occasionally required or that are not normally provided by the principal FIM agency.

Coordination between police, Emergency Medical Services (EMS), and fire departments is, for practical purposes, universal, so it is unlikely to constitute an untried organizational option. Similarly, mutual aid agreements between state and local or county police agencies are standard in most states. If these relationships do not exist, however, they should be seriously considered.

Some other relationships were encountered by PMM&Co. in the course of the field and telephone interviews. A number of state highway departments have developed ties with the state environmental protection agency (162, 239, 251). When incidents involving petroleum or hazardous chemicals occur, these pollution control agencies are immediately notified. In cases in which spilled liquids threaten to pollute navigable waters, the Coast Guard

is frequently called. Another unusual relationship was found to exist between a city's police department and its sanitation department (250). The police call the sanitation department rather than the highway maintenance department, to clean up nonhazardous spills. Finally, two cities' police departments have unique agreements with their respective local chapters of the American Automobile Association (AAA) (202). In one case, AAA supplies the police freeway patrol with gasoline, flares, tools, fire extinguishers, and other equipment for roadside service in return for getting all requests for wreckers over an AAA-supplied radio. The other example is similar in that the local AAA handles all wrecker dispatching for the police. Other than having one less administrative task to perform, the police in this city do not reap any tangible benefits from this arrangement.

Issues Common to All Organizations

As with the police/highway department relationship, inter-agency communications is an issue involved in this option. Sufficient planning must be undertaken to ensure that rapid notification is effected both during and after normal working hours. Otherwise, the benefit gained from establishing a recognizable relationship will be lost.

Assessment

Establishing an incident management-oriented relationship with other public agencies or interested organizations is an organizational option that is highly cost-effective. With an investment of time and energy only, a police or highway department can significantly improve the FIM system's ability to respond to unusual incidents requiring special resources. It is just this type of unusual incident that has the greatest potential for adverse effects upon traffic and the environment as a whole.

Ties with Transit Authorities

This organizational option involves the development of a relationship between the principal FIM agency and the local municipal transit authority. In most urban areas, buses are regular users of the freeways, and as such, represent a potential source of incident detection and traffic reports. Furthermore, transit authorities maintain heavy-duty wreckers that can be utilized for incident management purposes. Consequently, the goal of this option is to establish procedures for tapping this source of information and equipment. An important incentive for creating a FIM agency/transit authority relationship is the fact that it is mutually beneficial. It is in the interests of both organizations that traffic congestion due to incidents be minimized.

Only three examples of this option were discoverd in the course of the field and telephone interviews. First, there are two municipal transit authorities that have equipped every bus in their fleets with a two-way radio (136, 114). This communication capability is used primarily for dispatching, scheduling, and emergency purposes. A secondary application is the reporting of traffic conditions and incidents. These reports are compiled at central communications facilities, synthesized into metropolitan areawide reports, and broadcast over several commercial radio stations. In addition, specific incidents observed by bus drivers are reported by the centers to the police via direct telephone lines. This information is only voluntarily transferred to the police; no formal relationships exist.

The other observed transit tie exists between a state department of transportation and a municipal transit authority (132). The bus company, at the request of the DOT, will dispatch heavy-duty towtrucks to assist in removing disabled or damaged trucks from the city's freeways. In return, traffic reports generated by the DOT surveillance and control center are directly available to the transit company. As in the other example cited above, no formal relationship exists between the two organizations. It is merely an informal arrangement that has become incorporated into standard operating procedures.

Issues Common to All Organizations

The development of a relationship to utilize buses for incident detection assumes that the transit authority has already equipped its fleet with twoway radios. This can be an extremely expensive project to undertake. One of the authorities described above spent $1.8 million on communications equipment and spends another $9300 per month to operate the system. Furthermore, it should be recognized that buses travel primarily on surface streets, not freeways. This fact tends to limit the impact of a radio-equipped bus fleet on freeway incident management.

Assessment

From the FIM agency's point of view, it is desirable to establish a relationship with any regular user of the urban freeways. But realistically, the ability of a transit authority to contribute significantly to an incident management system is limited. Providing heavy-duty wreckers upon request is important, but his particular function is usually performed by private wrecker companies, and is therefore not critical. Radio-equipped buses serving as incident detectors would have more impact, but the cost of this capability is too high to justify on incident management grounds alone. Development of a relationship with an already radio-equipped transit authority is, however, an effective strategy for improving the detection function of a FIM system.

Citizen Group Liaison

The citizen group liaison option is the formation of a relationship between the principal FIM agency and citizen volunteers for the purpose of facilitating citizen participation in incident detection and reporting. Usually, the agency is a local police department, and the liaison involves the use of CB radio. This citizen group/police interaction may be sponsored by either of the two parties, but in most cases it is the police who oversee the joint effort. In many cities, they have organized and continue to sponsor CB monitoring clubs that report crimes and incidents directly to their CB base station. These programs often include training sessions in observation techniques and police radio procedures, and identification engraving clinics designed to combat CB theft. When the relationship is citizen-sponsored however, police participation is likely to be less active since long-standing CB clubs conduct their own membership and training programs. Furthermore, under these circumstances the base station is operated by citizens who screen the calls and pass the information on to the police via landline communications.

Examples of both police and citizen group-initiated liaisons were observed by PMM&Co. during this study. Three programs have already been described in Chapter 3 within the CB Detection Option section. Two others deserve mention here. The first is a CB organization sponsored by a midwestern city police department (110). This department obtained a Class 'D' (Citizens Band) license in 1973 that authorized 1,000 member/monitors to participate in a Channel 9 monitoring program. The police sponsor-coordinator was established as an ex officio member of the executive board, and has veto power over applications for membership. Although they have experienced problems getting people to monitor Channel 9, the police recently expanded the organization's membership to 2,000. Window stickers and membership cards are issued to all participants, thus creating esprit de corps within the organization.

The other example involves not only the municipal police department, but also the local chapter of the U.S. Jaycees (85). This service organization donated a CB base station to the police in the first phase of the program, a publicity campaign encouraging CB users to report incidents directly to the police via CB radio. In the second phase, the Jaycees and police co-sponsored a club open to licensed CB operators interested in assisting the police by reporting crimes, serious accidents, and hazardous conditions. Although it is ostensibly a citizen organization, the club remains under the effective control of the chief of police, who selects 6 of the 11 members of the board of directors. As in the case of the other police-sponsored CB club mentioned above, cards are distributed to identify members and promote organizational pride.

Issues Common to All Organizations

Level of Responsibility Involved. The central issue associated with a police/ citizen group relationship is the degree of citizen participation. Police departments seek timely, accurate reports of illegal activities, accidents, and hazardous conditions. They do not encourage direct citizen involvement in the emergency response to these reports. In fact, they stress the fact that even police-sponsored organizations have no police authority or enforcement powers. Still, some frustrated civilian "policemen" pursue drunken drivers and suspected criminals, or try to assume authority at an incident. Even organized CB users dedicated to assisting disabled motorists and accident victims are considered by most police agencies to be a hindrance to law enforcement officers. One enthusiastic club petitioned a local police department for the right to mount amber flashing lights on the roofs of their vehicles. This request was denied, reflecting a widespread police attitude: "Don't encourage what you can't control."

Communications Necessary. Issues concerning CB radio channel crowding and transmission interference have been discussed in Chapter 3. The problem of false reports was mentioned too, but an even greater problem for police agencies is the quality of the information on legitimate calls. Police officers complain that the average citizen has little ability to accurately describe crimes or incidents, or to clearly identify the location of these activities. This can result in needless dispatching or even worse, lengthy response time spent looking for the incident. It should be recognized, however, that these problems exist regardless of the reporting process used. Any effort to increase citizen participation in law enforcement runs this risk.

Assessment

Despite the problems attendant to it, a citizen group liaison can be an effective element in a freeway incident management system. The extension of the "eyes and ears" of the local police force can improve detection capability and, consequently, response time. Sufficient control must be maintained, however, to prevent the development of vigilantism. This possibility necessitates police review of applicants to police-sponsored organizations. Unfortunately, this still leaves many CB users who may or may not obey police wishes. Publicity campaigns and training programs dealing with the CB user's potential contribution to law enforcement are recommended. Finally, it should be remembered that under most circumstances, any police efforts to involve more citizens in law enforcement and safety will be enthusiastically received by the public.

Wrecker Contracts and Agreements

This organizational option involves the development of contracts, ordinances, or agreements to exert control over predominantly private towing services on urban freeways. Most wrecker contracts are between city, county, or state governments and private companies. Turnpike authorities often contract for towing service too, and at least one state has hired a county road commission to perform this function. Municipal ordinances usually establish licensing, equipment, storage, and insurance standards for private wreckers, and empower the police to dispatch wreckers and investigate citizen complaints about service. In addition, some ordinances regulate towing fees with the inclusion of a fee schedule. Agreements may exist between the police and local wrecker operators, or among the operators themselves. They usually deal with the method of distributing police requests for towtrucks among the qualified operators.

The primary purpose of wrecker contracts and agreements is to maintain 24-hour vehicle removal capability. In addition, they may attempt to ensure that response time is minimized and that service is reasonably priced. Another reason for developing them is that they can eliminate scavenging by marginal wrecker operations. Finally, another purpose may be to distribute wrecker requests fairly to all qualified operators.

The spectrum of this option ranges from loose regulations in the form of rotating call lists and licensing standards to closely monitored written contracts which control fees, areas of operation, and storage procedures, and which require the posting of a performance bond. The level of organizational involvement varies correspondingly from low-level operating procedures to high-level legislative efforts and contract monitoring. Another important variable in wrecker contracts and agreements is the defined area of operations. This ranges from an entire city or a portion of it, including surface streets, to a freeway area of operations exclusively.

Of the many wrecker contracts and agreements reviewed by PMM&Co. in the course of the field interviews, five have been selected for discussion here. Their characteristics constitute a representative sample of the variety of options open to police agencies seeking to control towing operators.

The first and most common example is that of a rotating call list maintained by the police (178). Requirements for inclusion on the list vary from city to city, but usually include, at a minimum, licensing, equipment, storage, and insurance standards. Often the police are required periodically to inspect both new applicants and old participants on a rotating call list. Dispatching is almost always handled by the police. An eligible operator is indexed into the circular card file, dispatched when his name appears in front of the file, and then placed at the back to await his next turn.

The next example is a bid contract issued by a county's Board of Commissioners of Roads and Revenues (42). The county has been divided into three service sectors, each of which is separately bid for. Equipment standards, storage procedures, insurance requirements, and a fee schedule are established in the one-year, renewable contract. In addition, the contractor must post a $5,000 performance bond and lease a direct telephone line to the county police communciations center. Service under the contract is rendered only upon request of the police and includes the removal of large dead animals, ordinarily a highway department responsibility. Although the three concessions are open to competitive bidding, the county awards them on the basis of the county's best interests and not on the bids alone.

The third example is of a turnpike authority that contracts with many towing companies for service between designated mileposts (125). Under the terms of the five-year agreement, the authority receives 10 percent of all gross receipts for service rendered on the turnpike. Furthermore, the authority sets rates by vehicle type and establishes equipment standards and regulations concerning on-site procedures. It also provides each wrecker with an authority radio, whose installation, rental, and maintenance costs are paid by the contractor.

The fourth example is an informal agreement worked out between a single state police troop and an association of towtruck operators serving that troop's district (35). The assocation assigns each 24-hour day to a single operator on a rotational basis. During that time, he is responsible for answering any requests from the state police as well as designating a backup operator for calls he cannot take himself. These requests are funneled through an answering service which is paid for by the participating operators. Thus, the state police benefit from the arrangement by having a single number to call for wrecker service. The operators, although they must pay for the answering service, save time and money because they then know when they must be available. Previously, a rotating call list system was used which necessitated that every operator be on call at all times.

The final example is similar to the one last described in that its distinguishing features are an informal collaboration of numerous wrecking companies and the use of an answering service. The city where these companies are located issued a request for bids to perform contract wrecker service throughout the city for two years (209). Recognizing that no one company could meet the contract's specification for a single wrecker telephone number, the operators formed a loosely-organized consortium and agreed that the winning bidder would "subcontract" (i.e. share) the business on the basis of predetermined zones. This is accomplished by having an answering service direct the request to the appropriate operator according to the vehicle's

location. Once again, each owner contributes money to hire the answering service, but benefits from the elimination of uncertainty and cut-throat competition. The uniqueness of this example is that the arrangements were made before the development of the contract, without police participation.

Issues Common to all Organizations

Cost. No direct capital or operating costs are incurred by police agencies or local governments in the development of wrecker contracts and agreements. In fact, revenue can be collected if a contract agreement is implemented. Two dollar cost issues are associated with this option, however, from the wrecker operator's perspective. First, a multi-year bid contract may not have provisions for cost-of-living increases. This situation concerns the operators, especially since operating costs are rising. The other issue involves a distortion of the competitive bidding process and the incurrence of a social cost. This happens when one wrecker operator bids unreasonably high for a concession contract, hoping to recover his expenditure by charging inflated prices for body or mechanical work not covered by the contract.

Administrative costs may be incurred if lobbying efforts for new legislation are required, or if a contract requires considerable monitoring time and complaint investigation. These latter overseeing duties are usually performed by the police regardless of whether or not a contract exists, in which case they do not represent significant additional costs.

Another cost-related issue is whether or not wrecker contracts illegally prevent some operators from getting business. This possibility is apparently avoided by the common police regulation that a motorist can summon any wrecker he chooses as long as it can arrive within a certain "reasonable," maximum time. Keeping this in mind, a wrecker contract can be looked at as simply a secondary, backup arrangement to ensure vehicle removal when a motorist cannot effect it on his own.

Level of Responsibility Involved. There are a number of issues regarding wrecker contracts or agreements and the responsibilities of public incident management participants, especially the police. First, there is some disagreement among police agencies over who should control wrecker companies. Most departments feel that it is a logical police responsibility because the police always get involved anyway and are the target of any citizen complaints about service. One department argues, however, that it is difficult to exert control over private sector people with whom they work closely everyday. Others would like to see wreckers controlled by the state corporation commission or the public utilities commission.

Another responsibility problem involves control of wreckers at the incident site. Some police officers avoid ordering towing operators around for fear of incurring liability should anything go wrong during vehicle removal. But when private operators are left to proceed on their own, they may be oblivious to traffic conditions and create needless additional congestion or hazardous conditions.

Accepting the responsibility for ensuring prompt wrecker response is another issue facing police agencies. This is extremely important for minimizing the occurrence of secondary accidents and the continuing danger to emergency personnel at the site. One police officer interviewed cited slow wrecker response as the major reason for the death of two officers at the scene of a truck overturn (160). This problem is exacerbated by the attitude of some towtruck operators (and citizens as well) that it is the patrolman's duty to stay at the incident site until it is cleared no matter how long it takes. Such an attitude ignores the urgency of the situation, and may result in a longer response time. To combat this problem, some police departments write warning letters to delinquent operators threatening suspension from the call list or termination of the contract. Although an immediate response to this threat is usually noticeable, police officers maintain that this is a recurring problem with no final solution.

Finally, the development of wrecker contracts and agreements necessitates recognition of and accommodation with existing service patrols and vice versa. This competition issue was mentioned previously in the discussion of dedicated freeway units. The reality of this potential problem was well illustrated when a state DOT service patrol was forced to terminate its activities due to complaints from wrecker companies on the state police call list.

<u>Communications Necessary</u>. The after-hours notification problem mentioned in the police/highway department relationship option is even more critical with regard to police/wrecker communications. After police response, wrecker response constitutes the most frequent need of freeway incidents. And, for the safety reason cited above, it is important that this response be prompt. Therefore, it is essential that a quick notification procedure be instituted. Many police agencies are demanding that a single, 24-hour wrecker telephone number be established. Answering services paid for by participating wrecker operators appear to meet this requirement best. They are not without their own problems, however. Some towing operators have complained that answering service employees are not familiar with city streets and are thus prone to making dispatching errors. Furthermore, the wrecker operators point out that a dispatch order loses its urgency and accuracy when it is subject to more and more transferring.

Assessment

The provision of prompt, adequate wrecker service is a fundamental characteristic of any successful freeway incident management system. Its importance cannot be overexaggerated. Particularly because of safety considerations, the wrecker role is crucial to incident cleanup. Despite this fact, controlling wreckers was often cited by interviewed officials as the major problem within existing systems. This situation suggests that there is considerable room for improvement. Written contracts and agreements appear to be the best method for introducing regularity into, and control over, wrecker performance. Although substantial effort may be necessary to create the appropriate legal environment for it, regulation is a goal worthy of considerable investment of administrative time. None of the issues mentioned above out-weigh the benefit of a wrecker contract or agreement. Besides, most of the attendant problems can be resolved in negotiations between local governments and private wrecker operators. The greatest problem, that of tardy responses, will have to be addressed. It may be necessary to innovate in this area and develop some type of incentive contract, because it appears that the current techniques that have addressed this problem have not always met with total success.

Private Sector Services Coordination

Private sector services coordination is the development of a working relationship between a FIM agency and private sector equipment contractors other than standard wrecker operators. These contractors supply specialized pieces of equipment such as heavy-duty wreckers, cranes, bulldozers, and defuelers that are needed to clean up the rare incidents involving heavy vehicles or unusual cargos. Because this equipment is difficult to muster, exotic incidents often cause extended delays. The purpose of this option is to initiate and maintain communications with contractors so that these resources are readily available when needed. To accomplish this goal, a police or highway department can establish notification procedures, operating agreements, and, when necessary, methods of compensation in advance of incident occurrences. Private sector services coordination ranges from informal agreements to guaranteed payment for services rendered.

Two examples of this option were observed by PMM&Co. in the course of the field interviews. In one state, the state patrol has developed a relationship with the petroleum carrying members of the state trucking association (108). They have collaborated on a notification procedure to be used in the event of a spill. During off-hours this involves the use of an answering service paid for by the trucking association. The service notifies the owner/operator of the damaged tanker, and, under the terms of a mutual aid agreement, the spill may be cleaned up by another petroleum

carrier at the owner's expense. This arrangement contrasts sharply with the situation in most states, where often the police must wait for the truck owner himself to respond. Originally a pilot program, the notification system and mutual aid agreement have now been successfully expanded statewide.

The other example is of a state DOT that guarantees the payment of contractors for the work they do at an incident (34). Previous to the implementation of this policy, crane operators would not respond to a state police request for help because they feared that they would be unable to collect payment for their services from the truck owner/operator. Unlike towtruck operators who can hold disabled vehicles until payment is made, crane and other specailized equipment operators have no way to coerce payment. Recognizing this problem, the DOT now guarantees payment to any contractor requested by DOT personnel, and pursues the truck owner/operator for payment. Initially, truckers worried that DOT bills for cleanup service would be unreasonably high, but to date, no complaints have been filed.

Issues Common to All Organizations

Cost. If a highway department or DOT decides to guarantee payment of equipment contractor bills, administrative costs would rise. Collection procedures for delinquent truckers can be time-consuming and ultimately unsuccessful. Even if payment is easily secured, the administrative costs of processing bills is significant.

Communications Necessary. As in the case of the police/highway department relationship, off-hours notification procedures are critical. Paging systems, however, are probably not justifiable because of the infrequent need for specialized equipment. Answering services appear to offer the best means of off-hours notification of private sector service contractors.

Assessment

Historical incident reconstructions have shown that a frequent cause of cleanup delay is the inability to dispatch a special vehicle or piece of equipment to the scene of a major incident. This is especially true of private sector vehicles and equipment. The private sector services coordination option is an effective method of facilitating private sector dispatch and performance. Granted, this option may be useful only for the more exotic, infrequent incidents involving heavy vehicles or unusual cargos, but these are precisely the kind of incidents that can easily cause lengthy delays.

Media Ties

Media ties are communication links between FIM agencies or citizen groups and the media, especially commercial radio stations. These links are used

to transfer traffic information such as the location and type of incidents, the extent of resultant congestion, the estimated delay, and possible alternative routes to radio stations for broadcast dissemination to the driving public. The primary purpose of media ties is to supply motorists with real-time (or nearly so) traffic information so that they can make informed decisions about what route to take. From the media's point of view, additional purposes are to perform a public service and to increase the size of their audience.

The spectrum of this option varies by the communications mode used and by the frequency of information transmission and dissemination. The former aspect ranges from conventional telephone to cathode ray tube links and includes dedicated telephones, teletypewriters, and radio. Traffic information may be transmitted to the media in regular peak hour reports and/or in random reports filed as incidents occur. Similarly, this information may be broadcast to the public on a regularly or arbitrarily scheduled basis depending on station policy and programming demands.

Four examples of this option have been chosen for discussion here. The first is a radio station or police department aircraft linked by radio or radiotelephone to a radio station (190). These aircraft usually fly only during the morning and evening peak periods and file traffic condition reports on a regular basis. Often a traffic division police officer will be assigned to fly in a radio station helicopter and will deliver the broadcast report via a communications patch. This technique is intended to lend reliability and accuracy to the reports.

The next example of a media tie exists between a metropolitan transit authority and several local radio stations (135). Under a contract agreement, the authority provides the stations with a summary of traffic reports filed by its fleet of radio-equipped buses and suggests alternate routes in the event of congestion. This is done every 30 minutes during the morning and evening peak periods. The stations may directly broadcast the summary as it is transmitted to them via leased telephone lines, or they may record or rewrite it for later airing. In any case, it must be aired within five minutes of the time it is provided by the authority. In return for these traffic condition summaries, the radio stations must provide a total of two minutes of public service announcement time per day for written or taped transit authority announcements.

The third media tie example is that between a CB radio monitoring club and local radio stations (148). The club receives CB reports of incidents and congestion and transmits them directly to one station via a cathode ray tube display, and to the other stations by telephone. The reports are filed as they are received from CB users on the highway, not on a scheduled basis.

In return for this service, the one radio station has supported the club with equipment and facility contributions.

The fourth example of this option is the teletype link between a major city's freeway surveillance and control center and local radio stations (132). It is used to transmit incident and congestion reports, but no attempt is made at forecasting delay. This teletype is supplemented by conventional telephone links over which the radio stations make inquiries to the control center.

Issues Common to All Organizations

Cost. The cost of a media tie depends in large part on the type of interface that is created between the traffic reporting organization and media organizations. Thus, it may be as inexpensive as conventional telephone service or as costly as cathode ray tube displays linked by dedicated landlines. Another cost consideration is the administrative time spent compiling and summarizing traffic reports. Fortunately, these activities usually benefit the organization performing them as well as the media. For example, the transit authority mentioned above uses its own traffic reports for dynamic rerouting purposes, and police agencies dispatch patrol cars in response to traffic conditions reports.

Measurement of Effectiveness. Serious questions exist concerning the reliability, accuracy, and timeliness of commercial radio station traffic reports. A recent study by Dudek et al (48) concluded that while commerical radio could play an important role as part of an effective real-time traffic information system, it currently falls far short of its potential. First, the study team found that only 19-35 percent of reported accidents were actually broadcast over the three stations monitored. Stalled vehicles were rarely reported, despite the fact that their average duration was only three minutes less than that of accidents. Furthermore, the average number of broadcasts per incident was only 1.3, and none of the radio reports that were monitored indicated whether an accident, previously reported, had been cleared. Finally, the time lag between incident occurrence and radio report ranged from one minute to one hour and 40 minutes with an average length of 25 minutes. The only encouraging finding of the study was that radio reports of traffic incidents were "generally correct" as to location.

Another problem with commercial radio traffic reports is their susceptibility to embellishment. One source reported that there is occasional competition between local stations to have the "worst" traffic report. Such a situation could have serious consequences for the accuracy and reliability of boadcast traffic reports.

Assessment

Media ties, especially with commercial radio stations, have great potential for providing motorists with real-time information about traffic incidents, congestion, and highway conditions. This statement is supported by another finding of the study cited above that 62 percent of the survey participants who had car radios and who would benefit from radio reports of freeway conditions, used radio traffic bulletins for trip planning during the peak period. In order for this potential to be tapped, however, the reliability, accuracy, and timeliness issues must be addressed. Reliability and timeliness can only be improved by the radio stations themselves, possibly under the pressure of a contract agreement. The accuracy of reports, assuming it is not lost in transmittal to the stations, is the responsibility of the organization making and/or compiling them. It can be improved through training in observation and reporting techniques, except in the case of the layman mobile CB operator. Finally, if the embellishment of reports by radio stations is a problem, then the FIM organization should take steps to ensure that their submitted reports are broadcast verbatim.

Freeway Telephone Trouble Number

This organizational option establishes a single, easily remembered telephone number for reporting highway incidents and requesting aid or information. Ideally, the number can be dialed from any pay phone without coin deposit. The purpose of this option is to facilitate citizen participation in the reporting of incidents, and thereby improve dispatching and response time. The existing spectrum of emergency telephone numbers includes the Universal Emergency Telephone Number (911) to be called in case of any type of emergency, and the Highway Emergency Long-Distance Phone Number (HELP) which is intended for highway-related emergencies only.

The 911 service is usually operated on a metropolitan areawide basis and requires coordination with the telephone company in order to be implemented. Specifically, equipment must be converted to accept the 911 number and permit 911 calls from pay telephones to be made without coin deposit. Other local emergency telephone numbers also exist, but they are conventional seven-digit numbers. Both types of local emergency reporting systems consist of a 24-hour call-handling center that receives general requests for police, fire, or ambulance service.

In contrast, some states have established HELP, an emergency telephone system specializing in calls from motorists reporting incidents, safety violations, and hazardous conditions, and/or requesting assistance. A typical statewide system consists of a long-distance, toll-free number that can be

dialed directly from a private telephone or through the operator from a pay telephone. The calls are taken by state radio network or highway patrol dispatchers who contact the appropriate emergency unit nearest to the caller. The HELP number appears on state road maps and driver's licenses and in pay telephone booths.[1]

Issues Common to All Organizations

A 911 service is not limited to highway emergencies and therefore requires the coordination and cooperation of all local emergency service agencies. Thus, a considerable administrative cost would be inccured if a FIM agency took the initiative to develop the system. Furthermore, there is some resistance to the implementation of 911 service from telephone companies and even police and fire chiefs. Telephone companies are concerned with the economic and technical difficulties attendant to modification of pay stations and switching equipment. Police and fire chiefs often oppose 911 services because they believe that an individual operator cannot be knowledgeable in both services to obtain all the necessary information from a caller. The 911 critics also fear that calls involving two persons (the 911 operator and the service's call-taker) can lead to difficulties such as delays in relaying information, garbled information, and divided responsibility.

The other telephone trouble number, HELP, has limited applicability on urban freeways. It is essentially designed for use in a rural environment where emergency response vehicles are scarce and must be dispatched from great distances away.

Assessment

Freeway telephone trouble numbers ensure that the person making an emergency call is put into contact with the appropriate response agency in the shortest possible time. It would be inefficient, however, to implement an exclusive system for highway emergencies in an urban environment. Instead, freeway incident management agencies should consult with fire, ambulance, and hospital officials and evaluate the development of a local 911 service to handle all emergency requests.

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[1] Highway Emergency Long-distance Phone Numbers (HELP): 1 for North Dakota--1800-472-2121; (2) for Iowa--1-800-362-2200. Note: Each telephone number is part of an inward WATS (Wide Area Telecommunictions Service) system and is dialable only from within the respective states.

PREPLANNING OPTIONS

As a result of the telephone interviews and site visits, PMM&Co. has formulated the following preplanning options: traffic operations training, a dispatcher's manual; communications training; a hazardous materials manual; alternate route planning; and an information digest.

Traffic Operations Training

Traffic operations training involves the instruction of on-site personnel, including policemen, firemen, and highway maintenance personnel, in traffic control techniques used to minimize congestion. These techniques include conventional manual control of traffic, the use of traffic control devices, the selection of alternate routes, and the general sensitization of incident management personnel to the importance of maintaining traffic flow. Often, on-site emergency workers perform their duties in isolation, oblivious to their detrimental effect on traffic flow. The purpose of this option is to train them to be more sensitive to the impact of their actions on traffic flow, and to suggest new ways of performing traditional duties in order to minimize possible adverse impacts. The spectrum of this option includes on-the-job training, lessons given as part of a basic training course, and sections in any agency's procedural manual. The decision to initiate or improve traffic operations training is made at a high administrative level, although the eventual outcomes, training courses or manuals, are incorporated into standard operating procedures.

Most of the police agencies interviewed rely upon experience to train their patrolmen in advanced traffic control techniques. Basic skills, such as vehicle placement, manual control, and overriding traffic signals are taught in courses at the police academy. But more subtle considerations, such as removing violators from traffic without disrupting flow or selecting detour routes with adequate height and tonnage capacity, are left to be discovered (often in hind-sight) in the field.

One state highway patrol, however, teaches its troopers some of the finer points of traffic management through the use of a freeway procedures manual (21). This manual explains that improper enforcement, traffic direction, and accident investigation techniques cause reductions of traffic flow. Among the methods it describes to counteract these adverse effects are regulating patrol speed; refraining from the use of flashing lights and sirens; and employing the proper stopping, escorting, and traffic breaking techniques.

Issues Common to All Organizations

The extent of an agency's traffic operations training depends heavily on that agency's service role. If service to motorists has a high priority, then techniques for maintaining traffic flow will be an important part of a training course or procedures manual. On the other hand, if enforcement of traffic laws or maintenance of the roadway are given high priority, then sensitivity to traffic movement will be a secondary consideration at best.

Assessment

The effect of traffic operations training on congestion and delay will be, in most cases, barely perceptible. Despite this fact, it is an effective option requiring little or no capital investment. If it succeeds in making FIM personnel aware of their influence over traffic movement at the site, then it will have fulfilled its primary purpose.

Dispatcher's Manual

The dispatcher's manual option is the development of a supplemental directory containing the location of and the primary, backup, and off-hours telephone numbers of all possible incident management participants and certain other informational items such as schematics of complicated interchanges, milepost identifiers, etc. This resource document is used by the principal FIM agency's dispatcher primarily to facilitate rapid contact with the variety of agencies, organizations, clubs, services, and companies that may be needed to clean up an incident, especially an unusual one. These providers of emergency resources often operate in only one jurisdiction or in certain geographic areas, so it is necessary to record the telephone number of resource providers for every location in which the FIM agency has authority. Advanced compilation and indexing of these resource telephone numbers and other incident related information prevent needless dispatching delay when an incident occurs.

The range of this preplanning option is directly related to the comprehensiveness of the manual. A basic manual contains the numbers of the most commonly requested emergency resources: police, fire, ambulance, and wrecker services. A more detailed dispatcher's manual lists special vehicle and equipment contractors; utilities; special hazard teams; federal agencies; cross-references to milepost locations, diagrams of interchanges, locations of pipelines, water lines, etc; and other less frequently needed information required for incident cleanup. Manuals also differ in the way in which they are organized. Some are arranged primarily on a subject

basis, and then secondarily on a service area or jurisdiction basis. Others are arranged in an opposite manner, first by jurisdiction or roadway section and then by subject area.

It is important to note that the dispatcher's manual referred to here is solely an incident management guide. As such, it will supplement other materials used by the dispatcher, either as a stand-alone document or through incorporation into a larger volume or series of volumes that collectively serve as a manual to guide the dispatcher's overall duties.

PMM&Co. inspected a variety of dispatcher's manuals in the course of the field interviews. Only one agency's manual, however, exemplifies the comprehensive document that is recommended here (62). For example, it contains entries for scuba divers; cowboys; pipeline and utility repairmen; postal inspectors; ordnance disposal teams; multicolored schematics of all interchanges; depths, diameters and pressures of pipes and their medium; and flooding information for rivers and streams. Furthermore, this information is cross-referenced by different subjects and by section of roadway. In contrast, many dispatcher's aids, manuals, handbooks, and directories were found that lack the depth necessary to avoid response delays for certain types of incidents, but that are adequate for the majority of incidents.

Issues Common to All Organizations

Developing a comprehensive dispatcher's manual requires the compilation of many telephone numbers and other kinds of information. Furthermore, the telephone numbers must be kept current by the dispatcher either by having him call these numbers periodically, or by requesting the emergency services to notify the dispatcher of any changes. Much of the other information can be kept current by keeping abreast of physical changes of the environment near the freeway. In additon, the manual must be revised to reflect any changes in administrative or political boundaries, such as an annexation. In any case, a significant administrative cost is incurred by the FIM agency. Many agencies argue that having an exhaustive manual is not worth this effort. The organization cited above, however, justified the administrative cost on the grounds that having a complete directory helped reduce total congestion time. Unfortunately, this position is based on subjective observations and cannot be substantiated quantitatively.

Assessment

The importance of having an effective dispatching function in a freeway incident management system cannot be overstated. More than any other person, the dispatcher is in a position to ensure that the system's

response to an incident is expeditious and sufficient. To achieve this level of performance, he must have immediate access to a comprehensive directory of emergency resources. The administrative costs of assembling this information and keeping it current appear to be small compared to the costs of additional congestion and delay that may be incurred in its absence.

Communications Training

The communications training preplanning option involves the instruction of telephone and radio operators in proper voice communications techniques for reporting and receiving information about freeway incidents. These techniques include following the FCC regulations that govern radio transmissions, using a standard reporting format to ensure accuracy and completeness, and practicing good voice quality and pronounciation so that messages are intelligible. These techniques should be made available through some active format to all the people who engage in incident-related communications including FIM agency dispatchers, police patrolmen, highway maintenance personnel, and civilian CB radio operators. Reporting techniques should be stressed, but lessons in eliciting quality reports, especially from untrained civilian observers, should be presented too.

The purpose of a communications training course is to improve the quality of detection reports, eliminate errors, and minimize communication time. The last goal is particularly important in radio transmissions given the almost universal interference and overloading problems associated with that mode. The spectrum of this option ranges from procedural manuals to on-the-job training accompanied by periodic examinations. Although training courses are initiated at the administrative level, their effect can only be observed at the operations level within a FIM agency.

Two communications procedures manuals were obtained by PMM&Co. in the course of the field interviews and site visits. The first is a mimeographed procedural guide used by a civilian CB-monitoring club in a major city (137). It sets forth the general principles and regulations of proper radio communications as well as the specific procedures the club uses to screen requests for police and to route calls to the appropriate agency or organization. In addition, it presents guidelines and instructions for the use of two other types of communication equipment, an electro-writer and a cathode-ray tube display.

The other manual is published by an association of public safety communications officers and reflects that organization's broad interest in the subject of communications (214). It includes chapters on telephone and

radiotelephone voice techniques, exhibits of the Ten Signal Aural Brevity Code (10-4, 10-22, etc.), the phonetic alphabet (Alpha, Bravo, Charlie, etc.), Greenwich time, the standard personal description (i.e., a fugitive description format), the standard log form, and a discussion of the FCC and its regulations.

It should be noted that both of the documents described above are written primarily for base station operators. This is logical in that the dispatcher is situated at the center of a communications system, and all transmissions except mobile to mobile ones require his active participation. This is not to deny, however, the importance of quality communications techniques to the mobile unit operator. In fact, for incident detection and reporting purposes, training for mobile operators should take precedence over that for dispatchers. This is especially true in the case of civilian CB operators, who generally have had no communications training whatsoever. To combat the inaccuracy and confusion of many CB reports, some police departments that monitor CB radio have conducted communications training sessions at local CB club meetings. Fortunately, CB-equipped truckers are considered to be a reliable source of incident reports by virtue of their extensive experience travelling the highways.

Issues Common to All Organizations

The issue of the reliability and accuracy of civilian CB radio reports reappears in this section after its initial consideration in the citizen group liaison organizational option. To reiterate briefly, police officials are often skeptical of the quality of CB reports. Inexperienced civilians tend to overexaggerate the danger of situations and give poor directions for response vehicles to follow, they argue. The communications training option then, presents itself as the logical solution to this problem. The fact is, however, that the majority of CB radio users are not associated with the clubs that are the logical forum for police training courses. Therefore, police officials will still have to tolerate a significant, untrained CB population.

Assessment

Comprehensive communications training should be a prerequisite for employment as a dispatcher. As mentioned previously in the dispatcher's manual option, the dispatching role in incident management is critical. And, since that role is to conduct emergency communications during an incident, adequate training is essential. The police officers and maintenance personnel who operate mobile units should also have communications training, particularly in reporting techniques. Finally, an effort should be made to improve the quality of citizen reports. Heretofore,

citizens have had passive training in the form of copies of FCC regulations or word-of-mouth interpretations of these regulations, which have failed to properly train many radio users. Perhaps some form of active training may have to be undertaken. This training may best be conducted through organized CB clubs or service organizations. In each instance, the benefit of communications training will be better message quality and reduced transmission time.

Hazardous Materials Manual

The hazardous materials manual option is the development of a reference document for use by field personnel and/or the base dispatcher in the event of an incident involving vehicles carrying hazardous materials. The manual is designed to aid in the identification of any hazardous cargo and the determination of subsequent precautions and stabilizing steps to be taken prior to cleanup. Identification of the general class of a hazardous substance (i.e., explosives, corrosives, radioactive substances, etc). is achieved through the recognition of the color-coded placarding mounted on the exterior of the truck. Most hazardous materials manuals reprint the standard placarding code as a minimum identification guide, and recommend general "dos and don'ts" for each class of materials depending on the fire and spillage circumstances.

A few manuals print a directory of commonly transported hazardous substances and provide detailed information concerning the seriousness, the type of hazard, the health hazards, the flammability, and the toxicity presented by each particular chemical compound. Such precise information is only of value, however, if the cargo manifest or bill of lading is recovered and the hazardous material is correctly identified. In addition to facilitating the identification of unknown cargos, hazardous materials manuals generally include the telephone numbers of emergency personnel from the local, state, and federal agencies that are responsible for actual cleanup.

The range of this option is very wide, depending as it does on the extent of precise cargo identification provided, the variety of hazardous situations described, and the level of on-site activity recommended. The compilation and organization of the information necessary to develop a hazardous materials manual would be done at a fairly high administrative level. Once completed, however, it would be used primarily at the operating level.

Of the many hazardous materials manuals collected by PMM&Co. in the course of its research, three will be discussed here. The first

is a debris and hazardous materials control and cleanup manual published by a rural state's highway department (251). In general, it advocates a passive role on the part of the personnel it is written for. Site protection activities are stressed, including keeping people away, preventing smoking, and stopping traffic. Notification of the "proper authorities" is a top priority item, and their home telephone numbers are provided. Hazardous materials are dealt with very broadly under the categories of explosives, chemical accidents, radioactive materials, and spills, and only very general precautions concerning exposure to them are made. Finally, this booklet includes sections on routine debris removal regulations, vehicle and highway debris, cargo spillage, normal maintenance, and animal removal, subjects not usually covered in a hazardous materials manual.

The second example is of a police agency-sponsored manual that concentrates on the broad classes of hazardous materials: explosives, flammable liquids, flammable solids, oxidizing materials, corrosive liquids, non-flammable compressed gases, flammable compressed gases, poisions, and radioactive materials (15). For each class, the appropriate placard and label are illustrated and a set of procedures is briefly described under each of four incident situations; accident/fire, accident/spillage, accident/no fire or spillage, and first aid. Furthermore, a column of "don'ts" corresponding to these four situations insures that policemen will not create additional hazards. Across from each class-devoted page are the local emergency telephone numbers to call concerning that particular class of hazardous material. Finally, this manual has a fire extinguisher chart colparing the characteristics of various types of extinguishers. Compared to the highway department manual previously described, this police manual allows and encourages policemen to assume a more active role at the incident scene.

The final example of this option, a manual written by a state DOT, lists 230 dangerous chemicals that are commonly transported by trucks (245). For each chemical, ten aspects concerning its harmful qualities are considered, and within each aspect there is a range of recommended procedures, descriptive characteristics, or degrees of danger associated with that chemical. The ten aspects are: seriousness, type of hazard, actions to take, first aid, health hazards, flammability, instability hazards, oral toxicity rating, action on skin, and fire extinguisher requirements. The aspect, action on skin, for example, has five categories ranging from "relatively harmless" to "any contact will cause serious skin disorder." Another example is the flammability aspect, which ranges from "will not burn" to "will rapidly or completely vaporize under normal conditions and will burn easily." The information about each chemical is arranged in a matrix with the ten aspects along the

top and the chemicals along the side. In each cell are numbers corresponding to a particular procedure, level of toxicity, degree of health hazard, etc. The aspects and their defined ranges are printed on either side of this matrix for easy reference. From this matrix a person can, provided he knows the name of a substance, determine the nature of the danger posed to him and follow steps to reduce the size of that danger.

Although these three manuals each offer a unique method of dealing with hazardous materials, they, and most other hazardous materials manuals, cite the same primary backup sources of information and assistance. Frequently cited sources include: National Agricultural Chemicals Association, Bureau of Explosives, railroads, refineries, liquid transport trucking companies, U.S. Atomic Energy Commission (now U.S. Nuclear Regulatory Commisson), Manufacturing Chemists Association's CHEMTREC (Chemical Transportation Emergency Center), the U.S. Department of Transportation, Environmental Protection Agency, U.S. Department of Agriculture, and others.

Issues Common to All Organizations

A concern voiced by more than one official interviewed is that hazardous materials manuals tend to present more information than is really needed by on-site personnel. This fact makes them difficult to use as the required information is often buried under useless filler. One highway engineer expressed the desire for a simple guide to dangerous materials handling that stressed what not to do. A related issue is the actual size and construction of the manual itself. Only one of the guides obtained by PMM&Co. is small enough to fit conveniently in the glove compartment of a vehicle. And none of them are protected in any fashion from the weather, especially wetness. As currently constructed, they would not last through a moderate downpour without suffering significant damage.

Assessment

The ability to consult a hazardous materials manual is an extremely important capability for a FIM system to have. Whether it is a simple, small version to be distributed to field personnel and/or a full-sized reference work kept in the dispatching center, it is essential for managing certain rare incidents involving dangerous cargos. Having a comprehensive manual in the dispatching center would solve the convenience problem in the field, but it might also create new problems on its own. Radio communications time would be significantly increased if a complete hazardous materials manual were not available in the field.

Alternate Route Planning

The alternate route planning option involves the predetermination of alternate routes for certain portions of a freeway system. The purpose of this preplanning option is to have the capability to implement a detour over surface streets immediately after a capacity-reducing incident occurs on the mainline. By cataloging street widths, curvature, grades, condition of surfacing, intersections, side friction, and turning radii, a highway department or city traffic engineering office can determine the optimal alternate route between two interchanges and can even install flip-down style signs for use in an emergency. The spectrum of this option ranges from established traditions for diverting traffic under a given set of circumstances to special point diversions to fully documented alternate route plans.

Two examples of alternate route planning have been studied by PMM&Co. The first is a widely publicized program in a major city that has an extensive freeway system (183). State traffic engineers have inventoried the surface streets adjacent to the freeway in order to design the best alternate route for a given portion of freeway. Once a route was designated between two interchanges, it was sketched on a map along with indications of the necessary traffic control devices and policemen to operate the detour. In addition, a matrix relating lanes remaining in service, time of day, and stages of implementation was developed for each freeway segment and placed on the appropriate map. Finally, the names and telephone numbers of the agencies responsible for effecting lane closures and the alternate route appear on the map. The program's managers estimate that 2,500 maps will be required to cover the 475 miles of freeway, but recent manpower cutbacks may curtail that extensive an effort.

The other example of alternate route planning exists at a single point on a freeway in a southeastern city (20). One particularly low underpass there fills up with water during heavy rains and prevents the passage of traffic. Just upstream of this location, the state DOT has installed permanent fold-down signs that divert traffic onto surface streets before it reaches the underpass, and then back onto the freeway beyond the problem area. These signs are manually activated by the local police, and are later folded up again when the water subsides.

Organizational Specific Issues

Many of the police officers interviewed expressed skepticism at the need for alternate route preplanning. They argue that beat patrolmen are familiar enough with their territory that they will immediately select the best detour through it on the basis of their experience. Furthermore,

police officers feel that their men are already burdened with too much equipment, so they are not particularly interested in assigning a large set of alternate route maps to each car. And, if the maps were to be kept at the station, the patrolmen would not have time to retrieve them. Even if someone else brought them to the detour site, any diversion will have been in progress long enough to resist change.

Assessment

The effectiveness of preplanned alternate routes depends heavily on the police agency's ability to set up an effective detour spontaneously. If beat patrolmen can select the best streets for diversion without measuring street widths, side friction, and turning radii then the only real benefit to be realized from preplanning will be increased inter-agency cooperation. If, on the other hand, allegations by traffic engineers that policemen do not know the best alternate routes prove to be true, then preplanned routes are an effective incident management technique. Alternatively, highway engineers can sensitize police officers to the factors that determine good alternate routes, and leave them to make the actual detour route decision on-site. In either case, an additional benefit of preplanning is the interagency cooperation that is fostered.

Information Digest

The information digest preplanning option involves the compilation of local information by a CB monitoring club for dissemination to predominantly out-of-town CB radio users on the highway. The purpose of this option is to save mobile operators from the trouble of stopping to read a map or pulling off the highway to search for a gas station, motel, or restaurant. In addition, it is hoped that the base station's provision of motorist information will encourage mobile units to call in incident reports. The spectrum of this option depends entirely on the extent of the information the base station prepares itself to provide. This could range from the location of a 24-hour restaurant to the vacancy situation in local campgrounds to local skiing conditions. Anything and everything that a traveler might want to know is a potential addition to the information digest.

Issues Common to All Organizations

Like the dispatcher's manual option, the information digest option requires administrative time during which someone can compile the information that will be included. In a volunteer CB radio monitoring club, however, this time does not "cost" anything to the organization. Rather, it is a question of the individual volunteer's time, and whether he wants to spend it collecting information for the digest.

Assessment

Although it is an admirable endeavor to answer requests for information, the information digest option has very little effect on freeway incident management. It may be responsible for fewer drivers stopping on the shoulder of the road and the availability of such an information service may encourage reporting of incidents that may not otherwise have been reported.

SUMMARY

With varying degrees of effectiveness, the administrative, organizational, and preplanning options discussed in this chapter can be implemented to improve an area's existing incident management system.

The administrative options have great potential for effectively improving a FIM system's ability to reduce congestion and delay. This is due in part to the fact that they are implemented by a single agency and require little or no capital investment. The effectiveness of each option can be briefly summarized as follows:

- Dedicated freeway units are very effective, especially when they are capable of performing both detection and response functions. This is due to the large number of incidents that are breakdowns requiring minor maintenance or repair. Furthermore, public response to freeway units is usually extremely enthusiastic, with the result that capital expenditures are more easily justified.

- The placement of response vehicles is an effective option when implemented at a point facility, but has little effect elsewhere.

- Accident investigation sites can be effective in reducing the incidence of gaper's blocks and secondary accidents. To reap the full benefit from them, however, a publicity campaign to dispel citizen misconceptions is necessary.

- Fast vehicle removal strategies are among the most effective options recommended by this study. Equipping police or DOT vehicles with pushbumpers is the best way to implement this option, but vehicle removal laws and abandoned vehicle time limits should also be pursued. Significant legal problems requiring investments of administrative time, may have to be overcome, however.

- A flashing lights policy is easily implemented, but its effectiveness is yet to be objectively evaluated. More research on this option is necessary.

The organizational options require considerable administrative time to implement, but still represent the options having the greatest potential for improving freeway incident management. This is due to the fact that they facilitate the cooperative efforts of a variety of

agencies and organizations concerned with incident management. Each option's potential effect can be described as follows:

- A police/highway department relationship is very effective because it ensures the cooperation of the two major FIM participants, and can eliminate any overlapping responsibilities that may exist.

- Relationships with other agencies are particularly effective when unusual incidents occur, for they predefine the roles of other agencies not normally involved in incident management.

- The effectiveness of ties with transit authorities depends heavily on the existence of a bus radio system and the number of buses traveling urban freeways. Without a radio system, a transit authority has little to offer to a FIM agency.

- A citizen group liaison involving the use of CB radio can extend the detection capability of a police agency, and result in improved community relations. It should, however, be kept under police control to avoid vigilantism and false reporting.

- The implementation of wrecker contracts and agreements represents the most effective way to ensure vehicle removal, and as such, constitutes one of the most important options formulated during this study. It takes on added importance in light of the fact that poor wrecker performance was the most frequently cited problem with existing systems.

- Private sector services coordination is effective in facilitating the contact and dispatch of unusual vehicles and equipment owned by the private sector. This option can significantly reduce the response delay that is usually associated with specialized resources.

- Media ties, especially those with commercial radio stations, have tremendous potential for providing a real-time motorist information system. Considerable effort must be made, however, to combat the reliability, accuracy, and timeliness problems that accompany this option.

- Freeway telephone trouble numbers are rarely used in urban areas. They are more properly combined with universal emergency telephone numbers in these areas.

The preplanning options appear to be the most easily instituted since they involve, for the most part, only one agency or organization and require little capital expenditure. Their impact on incident congestion and delay, however, can only be subjectively posited at this time, not objectively determined. Briefly, each option's effectiveness can be summarized as follows:

- Traffic operations training sensitizes on-site personnel to the impact of their cleanup activities on traffic flow, and suggests ways in which that impact can be minimized. Its effect at the scene of an individual accident, however, is barely perceptible.

- Development of a detailed dispatcher's manual can reduce dispatching time, and consequently, response time by eliminating the need to locate and notify emergency resources for the first time.

- Communications training, especially for the dispatcher, reduces radio transmission time and improves message quality. Its effectiveness is particularly significant when it is given to civilian CB operators.

- A hazardous materials manual, although infrequently used, is an extremely important resource for the FIM system to have. When a major incident involving hazardous materials occurs, it facilitates expeditious identification and cleanup of dangerous cargoes.

- Alternate route planning is the only preplanning option requiring more than one agency's participation. Its effectiveness is heavily dependent on current police and DOT capability in implementing detours.

- An information digest can have only a slight effect on incident management. Its existence may encourage the reporting of incident via CB radio, and it may prevent some motorists from making brief information stops.

CHAPTER 6

INCIDENT CHARACTERIZATION

The design and evaluation of a freeway incident management system requires knowledge of the frequency and characteristics of incidents. This implies the need for a clear definition of which events may be classified as incidents and the specification of those characteristics that are most useful for design and evaluation purposes. The definition of an incident adopted for this study, the two functional characterizations of incidents, and a selection of incident data extracted from the literature are presented below.

INCIDENT DEFINITION

The literature use of the term "incident" loosely applies to a variety of traffic-related events and seldom is clearly defined for any one study, much less for general purposes. Rather, the term has been used to describe those events which lay at the core of the particular study. No attempt will be made here either to reconcile all these various definitions or to suggest a universally applicable definition.

For purposes of this study, an incident will be defined as any accident, spill, breakdown, or stoppage occurring on an urban freeway for which remedial actions or countermeasures might be taken. This definition specifically excludes: brief, willful stops along the shoulder where the vehicle is completely under control and the driver is in command; enforcement activities of the police; and mowing, snow removal, or routine scheduled maintenance activities.

The remedial action definition implies a somewhat policy oriented basis for the inclusion or exclusion of specific events as incidents, depending upon the scope of the remedial actions. However, for this study, the definition is taken to be a fairly universal one, subject to the exclusions noted, with certain types of incidents not addressed under the specific options to which they do not apply.

Incident definitions in the literature are seldom explicit and must be ascertained from the context of the study described. Typically, two distinct definitions are implied. The first is similar to that noted above, in terms of most or all events that occur on a freeway. A variation is to restrict the definition to those events which have a significant impact on traffic performance, thereby excluding incidents that do not block a freeway lane.

The other general definition of an incident is used as a complement to "accident" in describing events on the freeway. Under this definition, any event which does not qualify as an accident becomes an incident and thus primarily includes breakdowns and stalls. In examining and evaluating any reported incident data, the context of incident specification must be known, at a minimum, and preferably a clear definition should be stated or inferred from the data.

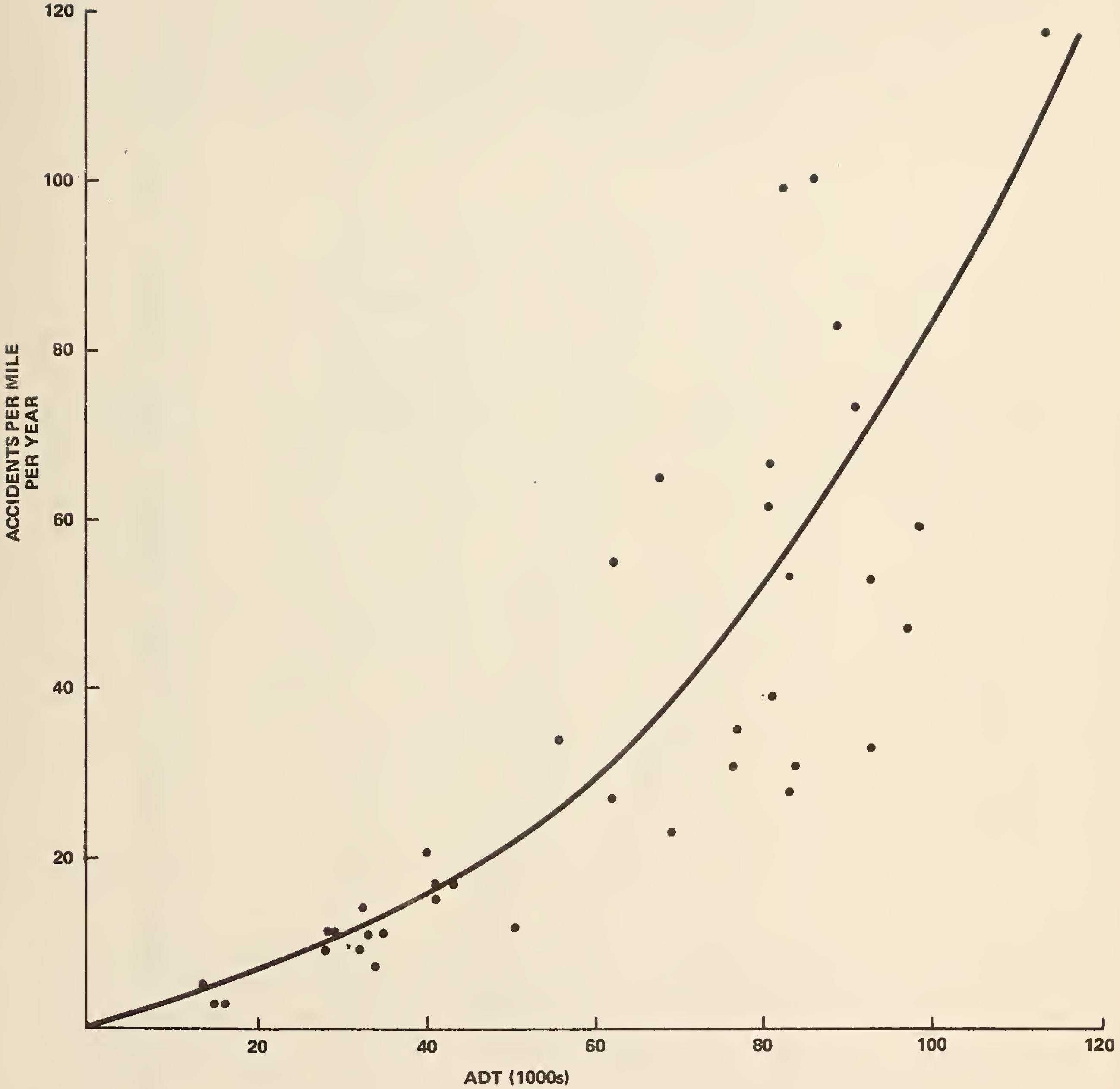
INCIDENT TYPES

Important factors in the design and evaluation of an incident management system are: the frequency of incident occurrence and the type of incident in terms of the nature of the response required. The former obviously serves as the baseline for all system sizing calculations and defines the basic demand for incident services. The type of response necessary to serve different incidents also provides direct input into determining the number and type of response vehicles and equipment required for a given level of incident frequency.

Few existing studies have comprehensively reviewed and analyzed all freeway incidents. Most emphasis has been on accident analysis and the prediction of accidents as a function of traffic volume, geometric design, and other factors. Actual accident data would probably be available for the planning or designing of any specific system for a particular area. In the absence of such data, or for preliminary analyses, simple relationships to readily available quantities, such as volume, length of roadway, and numbers of lanes, may be used.

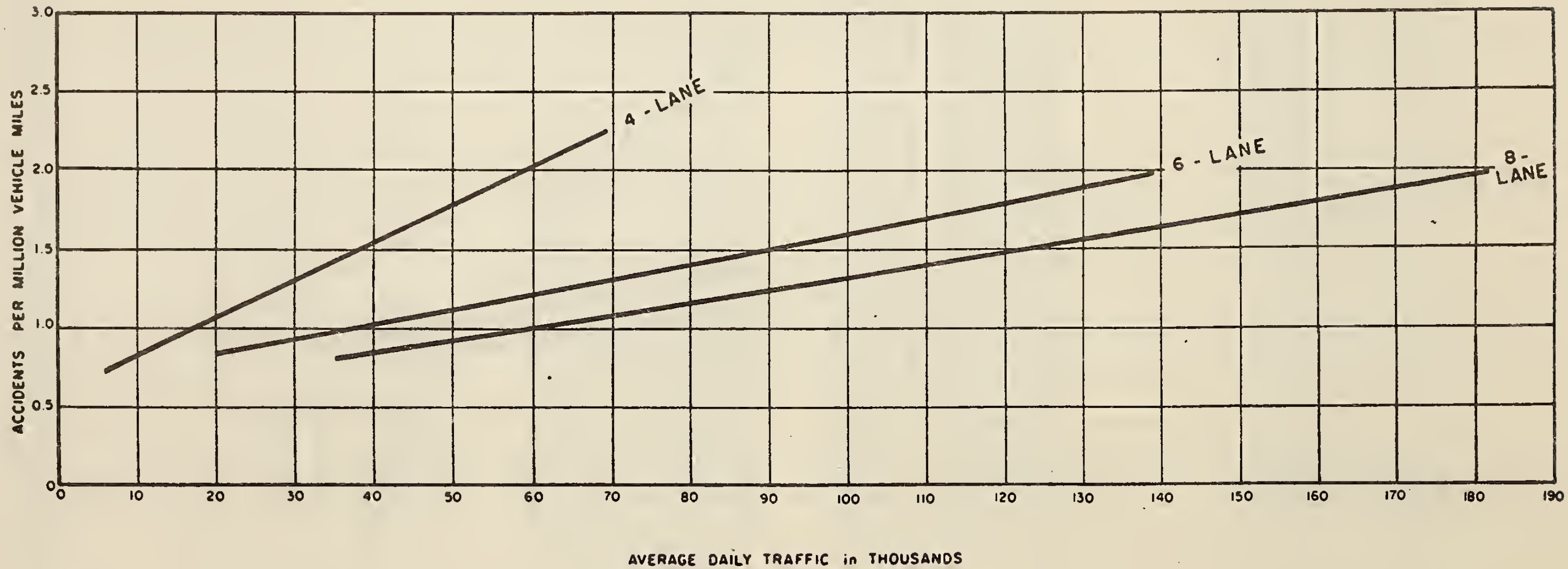
The simplest type of relationship would be the estimation of accidents per mile, per year as a function of average daily traffic (ADT). A hand-fitted curve to actual data for the State of Virginia for 1974 (236) is shown in Figure 2. Although these data include both urban and rural sections, the higher volume ranges generally represent the urban conditions. A further, useful refinement of this approach is to stratify the roadways by numbers of lanes, because a given ADT will yield a lower accident rate on a higher capacity facility. A frequently-cited chart, derived from 1964 data for California, (193) is given in Figure 3.

Far fewer studies have reported on the frequency of other non-accident incidents. The number of disabled vehicles on a 17-mile section of I-5 in Seattle has been estimated at 20,000 per year (181). These figures were estimated from assists reported by the Washington State Patrol. A much lower figure was reported for the Gulf Freeway in Houston (82) where 1,117 stalls were observed over a two-year period on the 6 and one half mile



SOURCE: (236)

FIGURE 2: ACCIDENTS PER MILE VERSUS ADT



SOURCE: (181)

FIGURE 3: ACCIDENTS PER MILLION VEHICLE-MILES VERSUS AVERAGE DAILY TRAFFIC

section of the Gulf Freeway covered by closed circuit television surveillance. This system was monitored only on weekdays from 6 AM to 6 PM, however, and recorded only events which blocked one or more traffic lanes. The Houston study also tabulated accidents observed in the same period; the re sults are shown in Table 5 below.

TABLE 5

INCIDENT FREQUENCY BY TYPE

Incident Type	Frequency	Avg. Per Day	Avg. Per Mile Per Day
Stalls	1,117	2.15	0.33
Injury Accidents	63	0.12	0.02
Non-Injury Accidents	1,091	2.10	0.32
Lost Load	37	0.07	0.01
Other	35	0.07	0.01
Total	2,343	4.51	0.69

Source (82)

Table 5 also indicates the relative frequency of injury and non-injury or property damage only (PDO) accidents. These results might be taken as typical of congested urban freeways with a high proportion of "fender-bender" accidents. For the Virginia statewide data used for Figure 1, the number injury accidents is much higher, 24 percent of the total in addition to 1 percent fatal accidents, representing the higher potential for injury at higher speeds on uncongested rural freeway.

Non-accident incidents have a broad range of causes. A sample of causes from several sources is given Table 5. For the I-5 study in Seattle, the state police estimated 12 percent of service requests were for gasoline. Many other sources exist, but most are for rural conditions and are associated with motorist aid situations and are thus not representative of an urban context.

TABLE 6

FREQUENCY DISTRIBUTION OF INCIDENT SERVICES

Type of Service	L.A. County	Study Wash. I-495	Houston Patrol*
Mechanical	25%	23%	47%
Tire Repair	19%	32%	32%
Gas, Oil, Water	14%	14%	21%
Non-Emergency	5%	–	–
Police and Fire	9%	7%	–
Information	–	4%	–
Miscellaneous	28%	20%	–

*Does not include miscellaneous, voluntary, non-disablement stops

SOURCES: (128), (84)

The characteristics of incidents reported in the literature point out the basic difficulty in using this type of data: the values reported are largely a function of the reporting method and the purpose of the particular study. Thus, results obtained in different ways are not readily comparable. For example, the I-5 study in Seattle reported a large number of service requests, largely because reporting was from a patrol system which operated under a highly service-oriented philosophy and stopped to investigate all apparent disabled vehicles detected. Call box reports, on the other hand, reflect the characteristics of those disablements where the use of the call box was appropriate.

The number and type of vehicles involved in incidents are also important system design parameters for determining: the degree of duplication required in the system, such as the number of wreckers available in a given location; and the requirement for specialized equipment such as heavy-duty wreckers. Summaries from Seattle are given in Tables 7 and 8. The number of accidents involving three or more vehicles accounted for only 15 percent of the total, but these, of course, were the most severe and most likely to cause major problems. Similarly, only about 4 percent of total accidents involved large trucks or buses but their impact on traffic is often catastrophic.

TABLE 7

NUMBER OF VEHICLES INVOLVED IN ACCIDENTS

1 vehicle	21.8%
2 vehicles	63.3%
3 vehicles	11.6%
4 or more	3.3%

Source (181)

TABLE 8

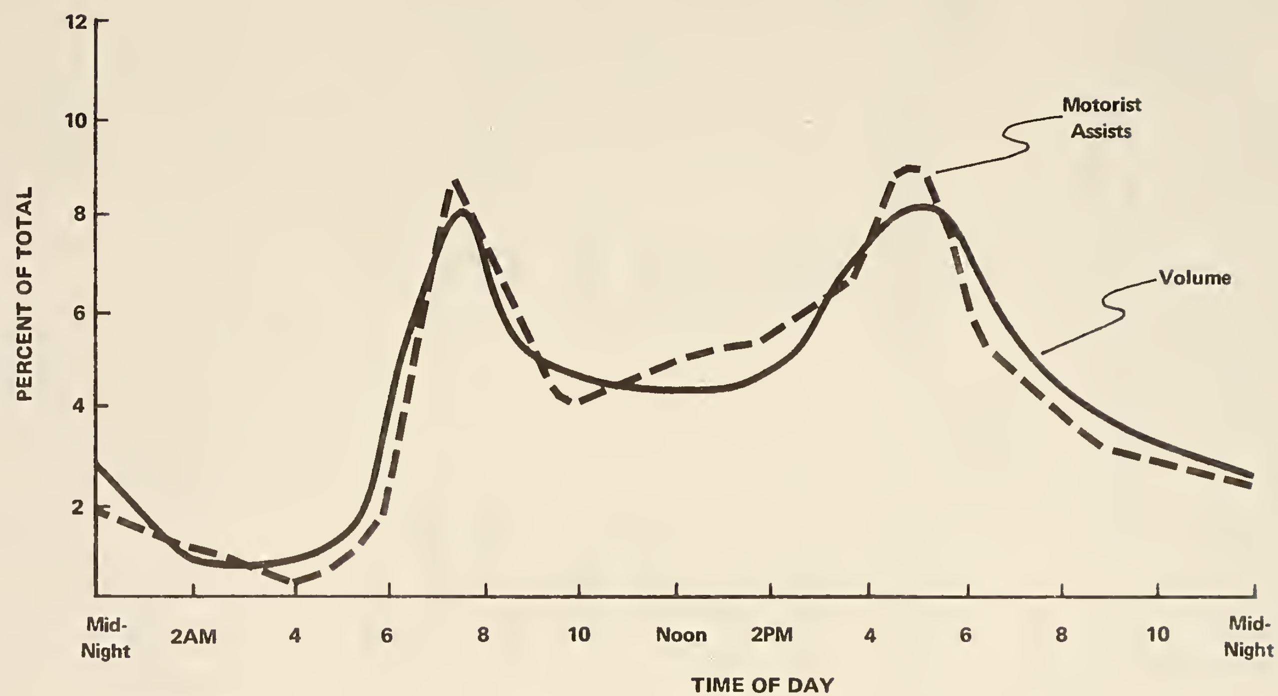
TYPE OF VEHICLE INVOLVED IN ACCIDENTS

Passenger Cars and Trucks under 10,000 lbs.	92.79%
Not Stated	2.10%
Trucks over 10,000 lbs.	2.50%
Truck and Trailer	0.26%
Truck Tractor	0.30%
Truck Tractor and Semi-Trailer	0.76%
Farm Equipment	0.04%
Taxi	0.23%
Bus	0.34%
School Bus	0.07%
Motorcycle	0.57%
Other	0.04%

Source (181)

Finally, the time at which incidents occur has a significant impact on system planning and operation, particularly for staffing during other than regular working hours. Much of the variation reported by time of day and day of week can be explained in terms of traffic volume. This relationship is particularly true for non-accident incidents which can be taken as a random phenomenon related to vehicle travel and which are not particularly influenced by other traffic or roadway characteristics. A simple plot of non-accident incidents by time of day against a typical volume profile is shown in Figure 4 where the degree of correlation is quite remarkable.

Accident rates show a somewhat different pattern, as was indicated in Figure 2 where accidents increased faster than volume, due to increasing congestion. Similarly, for the Seattle data, the proportion of accidents in the peak hours was higher than the relative volume or proportion of incidents.



SOURCES: (92, 181)

FIGURE 4: MOTORIST ASSISTS VERSUS VOLUME BY TIME OF DAY

Distribution of accidents by day of the week also shows pronounced peaking characteristics. Data for Seattle are shown in Table 9. The accident rate for any Friday is 75 percent greater than for any Monday. However, it is not likely that the traffic volume on Friday is 75 percent greater than on Monday. Similarly, the Saturday accident rate is greater than the weekday rates, but it is unlikely that the Saturday traffic volume is greater than the weekday traffic volume. The explanation may be the traditional increases in traffic accidents during evening and late night travel on the weekends.

TABLE 9

ACCIDENT OCCURRENCE BY DAY OF WEEK

Monday	12.2%
Tuesday	13.1%
Wednesday	12.9%
Thursday	16.5%
Friday	21.4%
Saturday	14.8%
Sunday	9.1%

Source (181)

TRAFFIC CONTROL CHARACTERISTICS

Certain incident characteristics are most important in the design and implementation of traffic control activities at the incident site. These characteristics often are more influenced by the conditions under which the incident occurred than by the nature of the incident itself, although the latter of course affects the type of response required at the site and influences the length of time required for incident treatment.

An important characteristic is the number of lanes blocked by the incident and which lane is involved. A comprehensive analysis of this type was performed by Goolsby for the Gulf Freeway in Houston (82) and is

summarized in Table 10 below. It should be noted that these data excluded all incidents occurring solely on the shoulder and not blocking a traveled lane. Table 10 indicates that stalls most frequently occurred in the right lane and seldom blocked more than one lane. Accidents were more evenly distributed across lanes, blocked more lanes, and occurred more frequently on ramps.

TABLE 10

EXTENT OF LANE BLOCKAGE

LANE BLOCKED	STALLS Number	STALLS Percent	ACCIDENTS Number	ACCIDENTS Percent
Outside	432	38.7	244	21.2
Center	231	20.7	204	17.7
Median	299	26.8	284	24.6
Two Lanes	8	0.7	111	9.6
Three Lanes	0	0.0	22	1.9
Ramps and Other	137	13.1	289	25.0
Total	1,117	100.0	11,154	100.0

Source (82)

The most important characteristic of incidents in terms of traffic control is their impact on traffic flow and delay. This impact is, in turn, closely related to the traffic volume at the time of incident occurrence. Any incident, including one on the shoulder, will reduce freeway capacity substantially. If the reduced capacity is significantly below the demand volume, queues and delays will develop and persist as long as the incident remains on the roadway or until demand is reduced through diversion or normal traffic fluctuations. Therefore, the key to successful traffic control through diversion is to match the relative demand volume with the remaining capacity at the incident site.

Data were collected on normal and constricted flow in Houston (82) and are summarized in Table 11. Although only lane blocking incidents were included in the analysis, a substantial number of incidents involved the removal of vehicles to the shoulder where additional accident investigation or

mechanical service was performed. Therefore, flow rates past a shoulder obstruction were measured as were flow rates under various blockage conditions.

TABLE 11

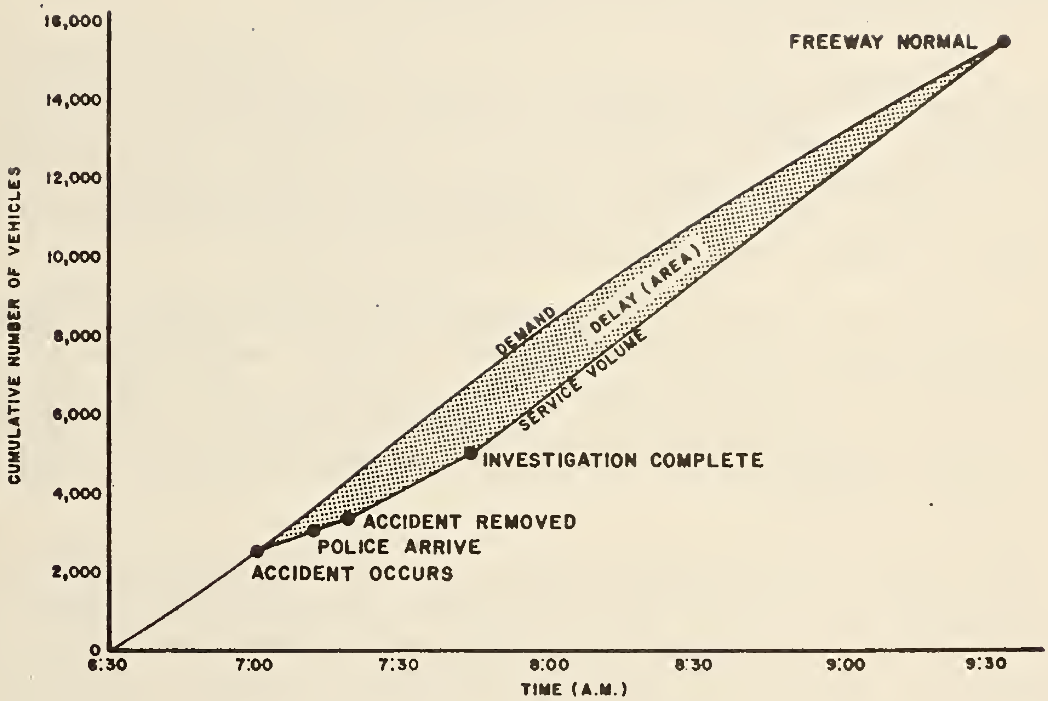
SUMMARY OF FLOW DATA AT FREEWAY INCIDENTS FOR THREE-LANE FACILITY

CONDITION	AVERAGE FLOW (veh/min)	FLOW RATE (veh/hour)
Normal Flow	92.6	5,560
Non-injury Accident, 1 lane blocked		
Outside Lane	48.1	2,880
Center Lane	42.7	2,560
Median Lane	46.1	2,770
Combined	45.8	2,750
Stall, 1 lane blocked	47.9	2,880
Accident, 2 lanes blocked	19.1	1,150
Accident on Shoulder	67.1	4,030

Source (82)

Data of this type can be used to make rough approximations of the times during which diversion should be considered. For example, with a single lane blocked, diversion need only be seriously considered when the flow rate on a three lane facility exceeds about 2,750 vehicles per hour. On many freeways, such volumes only occur in the peak direction for a few hours per day. For other highly congested freeways, such volumes may be exceeded for most of the daylight and early evening periods and diversion might be considered whenever an incident occurs.

The relationship between service volume and demand is shown graphically in Figure 5. Here, the area between the two curves represents unserved demand and subsequent delay. Reducing the elapsed time for any



SOURCE: (82)

FIGURE 5: EXAMPLE OF TIME-FLOW DELAY RELATIONSHIPS FOR AN ACCIDENT BLOCKING ONE LANE

of the incident activities would permit an earlier return to full capacity and reduce the area under the curve and thereby decrease delay. Such a relationship may be used to assess the effectiveness of an increased patrol frequency, to reduce response time, various site clearance options such as pushbumpers to reduce incident clearance time, and the use of off-site accident investigation sites to reduce gapers' blocks.

Finally, incident duration would appear to have significant impact on traffic control procedures. However, incident duration is not a direct characteristic of incidents themselves, but is primarily a function of the incident management procedures being used at the time. Thus, incident duration cannot be used directly for analyzing system alternatives, except as a baseline against which to measure improvements.

The components of the incident management process could, of course, be timed individually and used to construct durations under proposed systems. Components such as detection time, response time, site clearance activities, and non-productive time could be identified and analyzed separately. Such an analysis will, in fact, form a substantial part of the ongoing project activities.

Some limited data on total incident duration under existing systems are presented for illustrative purposes in Figure 6 and Table 12. Figure 6 illustrates incident durations on the Gulf Freeway in Houston and thus reflects strongly the existence of the highly sophisticated surveillance system used on the freeeway and the organized approach undertaken by police and highway department personnel in the area. In contrast, the data in Table 12 are those values obtained from field observations and reconstruction of the incidents by the project team. All of these observations were made under conditions of fairly low, but typical, detection and organizational capabilities.

SUMMARY

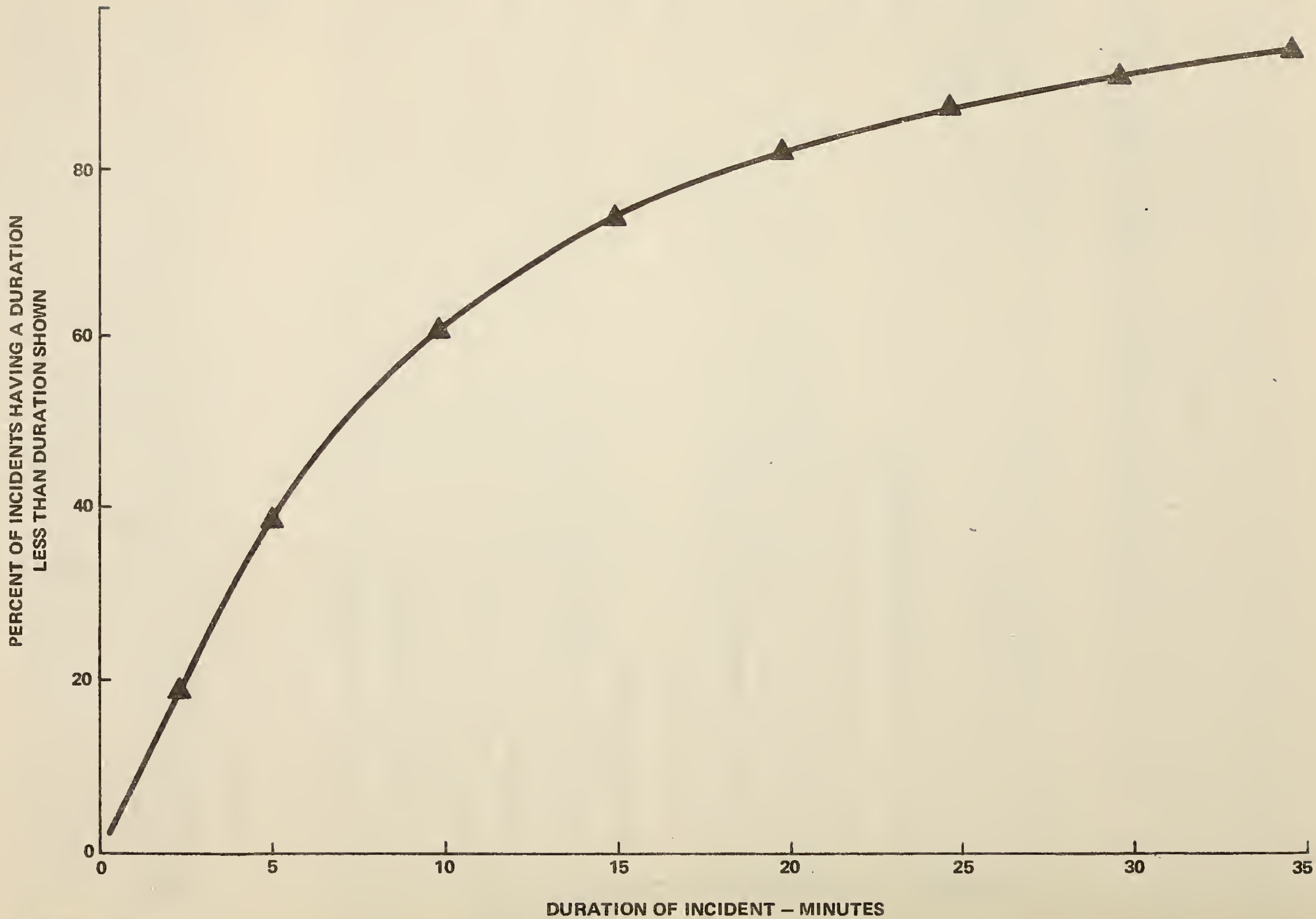
The design and evaluation of alternative freeway incident management systems require the development of detailed data concerning the frequency and nature of incidents. Unfortunately, reported data of this type are deficient in many respects, largely because the data have been collected for specific purposes, lack clear and unambiguous definition, and are often more reflective of the data collection methodology employed than the nature of the incidents themselves.

In spite of these problems, considerable use must be made of published materials. In addition to the references cited in this chapter, additional information will be sought in several areas. One of these areas will be the

TABLE 12

DURATION DATA FROM JHK & ASSOCIATES ON-SITE OBSERVATIONS

Type of Incident	Time Between Police Arrival and Incident Clearance
Hazardous material accident, 1 lane blocked	26 hours
Gasoline tanker explosion — complete closure	10 hours
Two tractor trailers	10 hours
Auto/trash truck collision — 4 fatalities	5 hours
Overturned dirt truck	3 hours
Disabled road grader	2 hours
7 vehicle collision in express lanes	1 hr. 10 minutes
Disabled auto	50 minutes
Disabled crane	45 minutes
2 car collision, minor injury	45 minutes
4 car collision, 1 lane blocked	23 minutes
Minor rear-end collision	11 minutes
Minor rear-end collision	10 minutes
Minor rear-end collision	10 minutes



SOURCE: (46)

FIGURE 6: CUMULATIVE DISTRIBUTION OF THE DURATION OF INCIDENTS ON THE GULF FREEWAY

estimation of the frequency of incident occurrence, particularly accidents, and in relating this to various roadway and traffic characteristics. Another area of further research will be the examination of the time periods involved in performing basic incident management functions, so that alternative systems can be specified and evaluated.

Finally, some necesary information will not be available from published sources nor will original data collection be possible. In these cases, professional judgment will be required to develop estimated values which can be used for planning purposes in the absence of definitive numbers. A simple example of this would be the proportion of vehicles involved in breakdowns and accidents that are movable under their own power. One way of obtaining such numbers is to ask knowledgeable law enforcement personnel to make their best estimate of the proportion and then to use an average of the reported values.

CHAPTER 7

SUMMARY AND CONCLUSIONS

Throughout this report, PMM&Co. has noted various conclusions that have been reached concerning each aspect of freeway incident management. These conclusions involved policy and procedural issues, as well as observations on a variety of technical matters. Some of the most pertinent of these conclusions are summarized in this chapter.

A number of general observations and conclusions about the overall freeway incident managment problem and process have emerged from the study. These include:

- improvements in traffic operations in general and freeway operations in particular are vital because of increasing environmental and energy conservation concerns and the virtual cessation of major freeway construction in metropolitan areas;

- high technology treatment of freeway operation problems, including incident management, is quite costly and involves a degree of sophistication and problem severity not found in most cities;

- the development of minimum investment freeway incident management systems must take full advantage of new techniques and opportunities available, particularly the potential of CB radio;

- the existing operating environment within a specific metropolitan area is crucial in determining the appropriate form of a freeway incident management system, as are the organizational structure and the roles of the various agencies involved in current activities; and

- alternative candidate incident management systems can best be structured around specific organizations that will take the lead role in establishing and operating such systems.

The crucial first step in the incident management system is the detection that an incident has taken place. A number of options are available to perform the detection function. Some conclusions concerning these options are the following:

- Roadside call box systems have generally fallen short of anticipated performance for incident management and motorist

aid use. System costs have generally been high, use relatively low, and operating problems sometimes quite serious.

- Patrol activities can combine many aspects of detection and response within the overall incident management system, as well as serve other agency functions. Operating costs, particularly in terms of manpower requirements, are a serious detriment under current conditions.

- Citizen band radio has experienced phenomenal growth in the past two years and represents a largely untapped resource for incident management. Incorporation of the CB radio into an incident management system is appealing because of low costs to the sponsoring public agency, but some reluctance has been expressed because of the difficulty in controlling the activity, which is outside the legal jurisdiction of the operating agency.

- Electronic detectors and television surveillance are quite expensive and probably beyond the scope of minimum investment systems except for extreme problem locations such as a bridge or tunnel.

- Human observers have very limited potential for freeway incident management applications.

- Aerial surveillance by helicopter or fixed wing aircraft is inordinately expensive for a minimum investment system. However, resources of existing aerial units such as commercial radio stations or police helicopters should be used if available.

The PMM&Co. team observed a number of actual incidents in the field and reviewed videotaped records of other events. Some of the observations from this activity were the following:

- The data collection effort afforded the project team an opportunity to review existing practices and problems and identify areas for potential high-payoff improvements.

- The successful handling of an incident at the site involves a relatively complex process including the assessment of needs, setting of priorities, and arranging for services. Specific deficiencies were noted in each of these areas.

- Traffic control at the incident site was generally considered to be adequate. Some lack of sensitivity to traffic problems and delays was observed when attention was focused on the incident itself.

- Motorist warning was not always adequate, particularly at night. This deficiency was largely caused by a lack of adequate hardware available at the scene.

- Diversion decisions are difficult to make at the scene and some remote assessment may be called for.

- Diversion, when undertaken, was often late and was not well organized due to lack of manpower and proper equipment.

- Motorist information through commercial radio broadcasts is often deficient in many regards and may cause additional problems.

- Wrecker availability is seldom a problem, although off-hours response was somewhat slow. However, arrangements for special equipment frequently resulted in lengthy delays.

- Special equipment such as pushbumpers could be used to great effect in rapid site clearance.

- Alternate methods of providing traffic control devices such as cones or special signs should be considered, such as caches of these devices at intervals along the freeway.

A number of administrative options are available to a particular agency attempting to improve its freeway incident management activities. Some observations and conclusions concerning these options are the following:

- The development of a dedicated freeway unit within a police department provides a great deal of flexibility in dealing with all types of freeway incidents. Considerable benefits will accrue to the motoring public and also to the police agency through increased public relationships. The option is expensive, however, and may run counter to the operating philosophy of the department.

- The placement of response vehicles in special locations to serve freeway incidents is probably not practical except for point facilities such as tunnels or bridges or particular high incident locations.

- The establishment of accident investigation sites off the freeway proper can be achieved at little cost and should reduce delays caused by gapers' blocks and eliminate hazards. Difficulties are involved in implementation regarding public awareness and education.

- Fast vehicle removal policies have small effect for specific incidents and may require legislative changes before implementation.

- Some research is currently underway to evaluate the effectiveness of alternative flashing lights policies and the trade-offs between site protection and creating additional hazards.

A number of issues were developed concerning the relationships among various agencies involved in incident management in a particular area. Some conclusions concerning these issues are:

- The most effective action that might be taken is the establishment of sound relationships at all levels between various police and highway agencies in the area. It is vital that the roles of each agency and their needs be clearly understood by the others. These relationships should extend to other issues in the overall traffic management and operations area.

- Relationships among other agencies should be established as well, with emphasis on those agencies which may become involved only infrequently in major incidents but are vital in successful handling of such events. Relationships among regular participants should also be improved whenever necessary.

- Ties with transit agencies are limited in most areas, but the capabilities should be included with other resources in the area. Particular attention should be given in those areas where the transit agency has installed two-way radios in its buses, and which travel over significant portions of urban freeways.

- Ties with citizen groups are extremely important to extend the detection capability of the freeway incident management agency. Care must be taken during the organization process to avoid creating vigilante-type activities.

- The relationship with tow truck operations is most frequently cited as the largest deficiency in current incident management practices. The experience of agencies using wrecker service contracts has generally been good and should outweigh the problems posed by agencies reluctant to engage in such arrangements.

- Private services are often required for handling serious events and adequate planning should be encouraged. Procedures might be instituted for reimbursement to ensure participation when needed.

- The reliability and timeliness of traffic condition broadcasts must be addressed by the incident management agency if this method of motorist notification is to be used successfully.

- A special freeway trouble number is probably not justified for incident management purposes alone but might be considered for joint use with other emergency service agencies in an area.

The freeway incident management agency might consider a number of preplanning options to improve their overall capabilities. Some of the more important observations in this area include:

- Improved traffic operations training should improve overall performance. Such training is relatively straightforward and is an inexpensive option.

- The preparation of materials to aid dispatchers involved in incident management is an important consideration. Materials must be prepared carefully and kept current for maximum benefit.

- Some improvement in communications training for both dispatchers and persons reporting incidents should improve the quality of information and reduce the load on the radio system.

- Hazardous materials manuals are only used very rarely but may be vital when required; careful design to accent the most valuable information is essential.

- Alternate route planning has potential benefits for dealing with major incidents. Large scale activities in this area are quite expensive. Acceptance by operating agencies, particularly police, may be limited because of the awkwardness in using materials prepared for this purpose and the attitude that such materials are unnecessary in that the police officer in charge at the accident scene is capable of making the necessary diversion decisions.

- An information digest is important for the operation of a CB-oriented system in that it encourages reports to a central location.

Finally, the project team examined existing incident data reported in the literature for its usefulness in planning and evaluating alternative incident management systems. Some general observations and conclusions concerning available data are the following:

- No clear definition of incident occurrence or classification has emerged from previous studies.

- Reported data are frequently a function of the data collection methodology used and the purpose of the particular study, rather than fully representing the phenomenon being observed.

- Accident studies have received considerable attention in the literature, while non-accident incidents have received much less; available figures indicate that the latter occur more frequently than accidents and often may have equally serious impacts on traffic flow.

- Relatively few incidents involve more than two vehicles and the overwhelming majority of accidents involve pas senger autos and light trucks. These findings have considerable implications for the design of an incident response system.

- The occurrence of non-accident incidents closely parallels the traffic volume profile on a facility. Accidents tend to increase somewhat faster than volume because of increasing congestion.

- The impact of any given incident on the delay to other vehicles is largely a function of the volume levels during the time that the incident remains on the roadway.

- Duration of incidents is largely a function of the existing incident management procedures in a particular area and thus does not represent an inherent characteristic of incidents; and

- Additional data development will be required for the study, including the estimation of certain items through professional judgement.

REFERENCES

1. Adler, B., et al., FLASH - A Cooperative Motorist Aid System, Airborne Instruments Laboratory, Deer Park, New York, July 1971.

2. Adler, B., I. S. Wisepart, and R. H. Emery, Evaluation of the First FLASH Installation, Highway Research Record No. 402, Washington, D.C., 1972.

3. Affiliated League of Emergency Radio Teams (ALERT 44), Vol. 3, No. 4, National Press Building, Washington, D.C., 1972.

4. Affiliated League of Emergency Radio Teams (ALERT 44), Vol. 4, No. 2, National Press Building, Washington, D.C., 1973.

5. Andrews, R. B. and L. E. Davis, et al., Methodologies for the Evaluation and Improvement of Emergency Medical Services System - Final Report, Contract No. NHTSA-FH-6849, Washington, D.C., July 1975.

6. Arizona State University College of Engineering Sciences, Engineering Research Center, Air Medical Evacuation Systems (AMES), Demonstration Project, Final Report, Contract No. FH-11-7090, Washington, D.C., June 1970.

7. Arthur, Lieutenant W. and Lieutenant Coy Johnston, Arizona Department of Public Safety, telephone conversations, March 8, 1976.

8. Association of American Railroads, Standard Transportation Commodity Code-Hazardous Materials, Washington, D.C., January 1, 1976.

9. Aug, S. M., "Citizen Band Radio is Biggest Headache for FCC," The Washington Star, Washington, D.C., October 17, 1975, p. A-8.

10. Baerwold, John E., Transportation and Traffic Engineering Handbook, Institute of Traffic Engineers, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1976, Chapter 19.

11. Baker, J. S., Traffic Accident Investigation Manual, The Traffic Institute, Northwestern University, January 1975.

12. Baker, J. L., "Radar, Acoustic, and Magnetic Vehicle Detectors," IEEE Transactions on Vehicular Technology, Vol. VT-19, No. 1, February 1970.

13. Barnet, M., British Toll Tunnels Dangerous Traffic, 21 Greenhill, London, England, April 1974.

14. Bauer, H. J., C. E. Quinn, and A. F. Malo, "Response to a CB Radio Driver's Aid Network," Highway Research Record No. 179, Washington, D.C., 1969.

15. Behrendsen, D. J., Guidelines to the Handling of Hazardous Materials, Source of Safety, Inc., Denver, Colorado, 1973.

16. "Better Roads, Emergency Patrols on Expressways," Forum, pp. 24-26, September 1966; Forum, p. 34, October 1966.

17. Black, W. E., "CB Radio? Sure I Have...Had One," The Gazette, Alexandria, Virginia, January 14, 1976.

18. Blahut, F. A., Memorandum to W. T. Davis, Subject: Jones Falls Expressway Patrol, Department of Transit and Traffic, City of Baltimore, Maryland, October 3, 1974.

19. Buffalo Police Department, Manual of Procedure, Buffalo, New York, May 1975.

20. Burnham, Archie, Traffic and Safety Engineer, Georgia Department of Transportation, interview, January 28, 1976.

21. California Highway Patrol, Freeway Procedures, January 1974.

22. California State Highway Patrol, Operation 500: A Study of the Effect of Increased Road Patrol, State of California, Department of Highway Patrol, April 1972.

23. Carmody, V. W., Proposal for Selective Traffic Enforcement Program, Jackson Police Department, Mississippi, November 19, 1975.

24. CB Newsletter, 4601 York Road, Baltimore, Maryland, June 1975.

25. Center for Auto Safety, Implementation of the 1973 Highway Safety Improvement Programs: A Counter-Report, Washington, D.C., March 1975.

26. Chattanooga, City of, Article IV.--Wrecker and Towing Service (of the Chattanooga City Code), Chattanooga, Tennessee, (undated).

27. Chayet, N. L., Legal Implications of Emergency Care, Appleton, Century, Crofts, New York, New York, (undated).

28. Chiarmonte, R. M., "Planning for Effective Utilization of Citizen Radio Volunteers," Bulletin, August 1971.

29. Chiramonte, R. M., and H. B. Kreer, "Measuring the Effectiveness of a Volunteer Emergency-Monitoring System in the Citizen's Radio Service," Highway Research Record No. 402, 1972.

30. Chow, W. and A. D. May, Analysis of Freeway Stationary Emergency Service Systems, Institute of Transportation and Traffic Engineers, University of California, Berkeley, California, August 1974.

31. Coleman, R. R., "Pennsylvania's Helicopter Ambulance Study," Highway Research Record No. 261, 1969.

32. Comptroller General of the United States, Actions Taken or Needed to Curb Wide-Spread Abuse of the Citizen's Band Radio Service, U.S. General Accounting Office, Washington, D.C., October 14, 1975.

33. Computran Systems Corporation, Traffic Surveillance and Control in the West Side Highway Corridor, April 1974.

34. Connecticut Department of Transportation, Commissioner's Administrative Memorandum No. 42 - Highway Debris Hazard Control and Cleanup, Wethersfield, Connecticut, January 15, 1975.

35. Connecticut State Police Department, Light Duty Tow Plan, Troop "G", Westport, Connecticut, October 1, 1975.

36. Cook, A. R. and D. E. Cleveland, "Detection of Freeway Capacity Reducing Incidents by Traffic Stream Measurements," Transportation Research Record No. 495, 1975.

37. Cook, L. "Citizen's Band Radio Fad Boosts Sales and Causes Problems for Government," Rutland Daily Herald, Rutland, Vermont, February 28, 1976, p. 2.

38. Cooper, C. and M. D. Powell, Description and Analysis of Eighteen Proven Emergency Ambulance Service Systems, National Highway Safety Bureau Contract No. FH-11-6686, 1968.

39. Costello, H., "Van to Help Stranded Motorists," Tampa Times, Tampa, Florida, February 4, 1976.

40. Daniels, E., M. Levin, and J. J. McDermott, Driver Attitudes and Behavior Regarding the Commercial Radio Traffic Report, presented at the 55th annual meeting of the Transportation Research Board, Washington, D.C., January 1976.

41. Dawson, W. S., "Smokey in the Blue Wrapper with a Camera at Milepost 50...," The Police Chief, Gaithersburg, Maryland, July 1975.

42. DeKalb County Police Department, Specifications, Requirements, Terms and Conditions (pertaining to wrecker contracts), Decatur, Georgia, March 1970.

43. DeKalb County Police Department, Supervisors Personnel Management Manual, Decatur, Georgia, (undated).

44. Delibert, A., et al., The Yellow Book Road: A Failure of America's Roadside Safety Program, Center for Auto Safety, Washington, D.C., 1974.

45. Detroit, City of, and University of Michigan, Emergency Medical Services for an Urban Area: Summary, Mayor's Committee for Community Renewal, Detroit, Michigan, July 1970.

46. Dudek, Conrad L., Better Management of Traffic Incidents - Scope of the Problem, Texas A. & M. University, College Station, Texas, August 1974.

47. Dudek, C. L., and J. D. Carvell, Jr., Feasibility Investigation of Audio Modes for Real-Time Motorist Information in Urban Freeway Corridors, Texas Transportation Institute, Texas A. & M. University, College Station, Texas, Report RF 958-8, April 1973.

48. Dudek, C. L., J. D. Friebele, and R. C. Loutzenheiser, "Evaluation of Commercial Radio for Real Time Driver Communications on Urban Freeways," Highway Research Record No. 358, 1971.

49. Dudek, C. L., and C. J. Messer, "Incident Detection on Urban Freeways," Transportation Research Record No. 495, 1974.

50. Dudek, C. L., C. J. Messer, and A. K. Dutt, "Study of Detector Reliability for a Motorist Information System on the Gulf Freeway," Transportation Research Record No. 495, 1974.

51. Dudek, C. L., G. D. Weaver, G. P. Ritch, and C. J. Messer, "Detecting Freeway Incidents Under Low-Volume Conditions," Transportation Research Record No. 533, 1975.

52. Dunlap and Associates, Inc. Economics of Highway Emergency Ambulance Services - Final Report, Contract No. FH-11-6541, Washington, D.C., July 1968.

53. Earnhart, B., Intradepartmental Communication to Chief Lavell Tullos, Subject: Information Concerning the STEP Program and Three Proposed Funding Plans, Jackson Police Department, Mississippi, January 29, 1976.

54. Ekey, P. W., A Comparison of Two-Way Voice and Push Button Motorist Aid Systems, Public Works, April 1974.

55. "Emergency Services Called Weak Link in Nation's Health System," U.S. Medicine, Washington, D.C., September 15, 1972.

56. Evereall, Paul F., Urban Freeway Surveillance and Control - The State of the Art, U. S. Department of Transportation, Federal Highway Administration, Washington, D.C., June 1973.

57. Fairfax Police Department, Towing Agreement, Fairfax, Virginia, May 7, 1974.

58. Fales, E. D., Jr., "Two-Way Radio for Your Home and Car," Parade, Washington, D.C., November 16, 1975.

59. Feaver, D. B., "Crash, Fire, Kill Driver, Jam I-495," The Washington Post, Washington, D.C., October 30, 1975.

60. Federal Communication Commission, How to Use CB Radio, Washington, D.C., February 1972.

61. Federal Register: Federal Communications Commission, Medical Communications Services, Government Printing Office, Washington, D.C., July 16, 1974.

62. Feltz, Michael, Communications Division, Illinois State Toll Highway Authority, interview.

63. Feltz, M. E., Standard Operating Procedures for Operation of the Illinois State Toll Highway Authority Telecommunications Complex, Schaumburg, Illinois, October 17, 1975.

64. Fendell, B., "CB as New-Car Option Seen for Next Year," Automotive News, New York, New York, January 5, 1976.

65. Fisher, Stuart, San Antonio Traffic Engineer, telephone conversation, March 2, 1976.

66. Flanagan, P., and J. Fortuna, "A Bookshelf on Injury Control and Emergency Health Services," American Journal of Public Health, New York, New York, April 1974.

67. Fleischer, G. A., Cost-Effectiveness of Mass Media Communications as Related to Highway Safety, Department of Industrial and Systems Engineering, University of Southern California, Technical Report 70-3, May 1970.

68. Florida Department of Transportation, The Howard Franklin Bridge Safety Study, Tallahassee, Florida, March 1974.

69. Forster, H., A. Kuprizanow, and F. B. Pogust, Patrol Effectiveness in the Detection of Stopped Vehicles, Airborne Instruments Laboratory, Deer Park, New York, January 1965.

70. Foster, W.M., Assistant Director for Highway Development, Washington State Highway Commission, interview, February 9, 1976.

71. General Services Administration, Code of Federal Regulations: Title 23 Highways, Washington, D.C., April 1, 1975.

72. General Services Administration, Code of Federal Regulations: Title 47-Telecommunications, Washington, D.C., 1975.

73. Georgia Department of Public Safety, 1974 Annual Report, Atlanta, Georgia, 1974.

74. Georgia Department of Public Safety, Traffic Crash Control and Cleanup, Atlanta, Georgia, 1974.

75. Gerlough, D. L., and K. S. P. Kamar, Computer Traffic Control - A Report of the Workshop Held March 20-22, 1974, Wayzata, Minnesota.

76. Gilbert, O. A., "HAZCHEM - The Principles, Interpretation and Application," The International Fire Chief, Washington, D.C., Vol. 42, No. 1, 1976.

77. Gildea, W., "CB License Applications: Too Hot to Handle," The Washington Post, Washington, D.C., March 9, 1976, p. B1.

78. Gladstone, E. A., and T. W. Cooper, "State Highway Patrol Functions and Financing," Public Roads, Vol. 34, No. 5, December 1969.

79. Goodson, G. L., "Manpower Allocation and Counter Measure Evaluation," Transportation Research Board Special Report No. 153, August 1974.

80. Goodwin, W. A., "Legislation for Increased Highway Safety," Transportation Research Board Special Report No. 153, August 1974.

81. Goolsby, M. E., "Accident Reporting and Clearance Procedures on the Gulf Freeway," Texas Transportation Institute Research Report No. 139-1, (undated).

82. Goolsby, M. E., "Influence of Incidents of Freeway Quality of Service," Transportation Research Record No. 349, Washington, D.C., 1971.

83. Goolsby, M. E., and W. R. McCasland, "Evaluation of an Emergency Call Box System," Research Report 132-1F, Texas Transportation Institute, December 1969.

84. Goolsby, M. E., W. R. McCasland, "Use of an Emergency Call Box System on an Urban Freeway," Highway Research Record No. 358, Washington, D.C., 1971.

85. Green, J. C., Operation Crime Watch, Jackson Police Department, Mississippi, (undated).

86. Greensboro, City of, Application for Wrecker Service, Greensboro, North Carolina, (undated).

87. Greensboro Police Department, Departmental General Order 66-6 (Disaster Control Plan), Greensboro, North Carolina, April 2, 1975.

88. Greensboro Police Department, Departmental General Order 66-7 (Abandoned Vehicle Procedures), Greensboro, North Carolina, September 21, 1966.

89. Greensboro Police Department, Departmental General Order 72-1 (Wrecker Service to the City), Greensboro, North Carolina, July 1, 1972.

90. Harkness, R. C., Communication Innovations, Urban Form and Travel Demand, Contract No. UMTA-URT-3-71, Washington, D.C., January 1972.

91. Hart, Irwin, "Changeable-Message Signs," Highway Research Board Special Report 129, Washington, D.C., 1971.

92. Highway Capacity Manual, Highway Research Board, Washington, D.C., 1965

93. "Highway Phones Blasted by Newspapers," CB Today, Vol. 1, No. 2, February 1976.

94. Hulbert, Slade and Beers, Inc., "Research Development of the Changeable-Message Concepts for Freeway Traffic Control," Highway Research Board Special Report 129, Washington, D.C., 1971.

95. Illinois State Department of Transportation, District 1, Snow Control Manual, Schaumburg, Illinois, September 1975.

96. Illinois State Toll Highway, Emergency Road Service Rules and Regulations for Tow Trucks and Service Vehicles, Oak Brook, Illinois, (undated).

97. Illinois State Toll Highway, Ambulance Road Service Rules and Regulations, Oak Brook, Illinois, (undated).

98. Illinois State Toll Highway, Maximum Fees for Ambulance Service on the Illinois State Toll Highway, Oak Brook, Illinois, (undated).

99. Illinois State Toll Highway, Maximum Fees for Wrecker Service on the Illinois State Toll Highway, Oak Brook, Illinois, (undated).

100. Illinois State Toll Highway, Questionnaire and Application for Ambulance Services, Oak Brook, Illinois, (undated).

101. Illinois State Toll Highway, Questionnaire and Application for Disabled Vehicle Services, Oak Brook, Illinois, (undated).

102. International Bridge, Tunnel, and Turnpike Association, Inc., Emergency Services on U.S. Toll Roads, Washington, D.C., August 1973.

103. Isringhausen Railroad Specialists, Inc., Ring Isringhausen (brochure), Jerseyville, Illinois, 1974.

104. Jain, R., "Highway Emergency Motorist Communications System," Public Works, December 1974, pp. 58-61.

105. Jellicorse, J. L., "Breaker, Break, Got Your Ears On?" Pace, Greensboro, North Carolina, January-February 1976.

106. JHK and Associates, Motorist Aid Systems Study - Interim Policy Report to FHWA, Contract DOT-FH-11-8745, San Francisco, California, September 1975.

107. Johnson, R. T., "Freeway Pedestrian Accidents," Highway Research Record No. 99, Washington, D.C., 1965.

108. Jordan, Captain R. L., Washington State Patrol Inter-Office Communication to All District II Lieutenants and Sergeants, March 21, 1975.

109. Juge, J. D., K. R. Kennedy, and T. C. Wang, Early Detection and Rapid Removal of Disabled Vehicles and Other Hazards from the Freeway, Vol. II - Rapid Removal (Emergency Tow Service), Vol. III - Airborne Television System - Incident Management Team, Vol. IV - Tow Truck Manual, prepared for National Highway Traffic and Safety Administration, June 1974.

110. Kansas City, Missouri Police Department, Bylaws for the Emergency Radio System, Kansas City, Missouri, (undated).

111. Keller, H. A., Summary of Selected Detection and Service Systems in the United States, Working Paper 35, Operations Research Center, University of California at Berkeley, August 1969.

112. Keller, H., An Analysis of Freeway Emergency Service Systems, University of California at Berkeley, August 1969.

113. Kelley Scientific Corporation, Jones Fall Expressway Surveillance and Control System, Washington, D.C., 1971.

114. Kelly, Michael, Director of Radio and Television Communications, Port Authority of Allegheny County, telephone conversation, December 1975.

115. Keryeski, J. M., and V. H. Surti, Effect of Television Surveillance on Police Response Time to An Urban Freeway Incident, National Proving Ground for Freeway Surveillance Control and Electronic Aids, John C. Lodge Freeway Traffic Surveillance Control Research Project, January 1965.

116. Kurtzweg, C. L., and D. L. Hoffman, Impacts of Surveillance Control and Driver Information Systems on Environmental and Community Goals of Seattle, Washington, presented at the 45th annual meeting of ITE in Seattle, Washington, August 1975.

117. Leon, G. and L. G. Sands, Dial 911: Modern Emergency Communications Networks, Hayden Book Company, Inc., Rochelle Park, New Jersey, 1975.

118. Lewis, P. "CB Radio: Tuning in on the Same Wave Length - Without Commitment, Without Threats," The Washington Star, Washington, D.C., February 3, 1976.

119. Liem, Commissioner Hugo O., Jr., Baltimore Department of Transit and Traffic, telephone conversation, March 15, 1976.

120. Lu, C. K., and A. D. May, Analysis and Design of Freeway Incident Response Systems, Report No. DOT-TST-75-95, Washington, D.C., November 1974.

121. Lunefeld, H., R. G. Varady, and H. Newburg, Post-Crash Communications, prepared for the U. S. Department of Transportation, National Highway Safety Board, July 1970.

122. Lynch, F. L., and C. J. Keese, Restoring Freeway Operations After Traffic Accidents, Texas Transportation Institute, Bull. 28, 1964.

123. Manual on Uniform Traffic Control Devices, U. S. Department of Transportation, Federal Highway Administration, Washington, D.C., 1971.

124. Manufacturing Chemists Association, CHEMTREC-Chemical Transportation Emergency Center, (brochure), Washington, D.C., (undated).

125. Massachusetts Turnpike Authority, (untitled wrecker contract), Boston, Massachusetts, (undated).

126. Mast, T. M., and J. A. Ballas, Diversionary Signing Content and Driver Behavior, presented at the 55th annual meeting of the Transportation Research Board, Washington, D.C., January 1976.

127. May, A. D., Optimal Design and Operation of Freeway Incident Detection-Service Systems: Interim Report, U.S. Department of Transportation, Office of the Secretary, Washington, D.C., November 1974.

128. May, A. D. and C. K. Lu, "Analysis and Design of Freeway Incident Response Systems," Institute of Traffic and Transportation Engineering, 1974.

129. McCasland, W. R., "Experience in Handling Freeway Corridor Incidents in Houston," Transportation Research Board Special Report 153, Washington, D.C., August 1974.

130. McCormick, J. A., State-Wide Emergency Services, presented at the Emergency Medical Services Session of the 78th annual IMSA Conference, New Orleans, Louisiana, August 14, 1973.

131. McDermott, J. M., "Incident Surveillance and Control on Chicago-Area Freeways," Transportation Research Board Special Report No. 153, Washington, D.C., August 1974.

132. McLean, Charles, Illinois Department of Transportation, interview, November 18, 1975.

133. McShane, W. R. and L. J. Pignataro, Some Results on Guidelines for the Treatment of Traffic Congestion on Street Networks, presented at the 55th annual meeting of the Transportation Research Board, Washington, D.C., January 1978.

134. Meister, E. C., "Advance Planning for Emergency Handling of Highway Traffic," Transportation Research Board Special Report No. 153, Washington, D.C.

135. Metropolitan Atlanta Rapid Transit Authority, Agreement (with a radio station), Atlanta, Georgia, (undated).

136. Metropolitan Atlanta Rapid Transit Authority, Specification for Radio Communication, Atlanta, Georgia, (undated).

137. Michigan Emergency Patrol, Information and Procedures for Base Operations, Detroit, Michigan, September 1975.

138. Michigan Emergency Patrol, Michigan Emergency Patrol Q & A, Detroit, Michigan, (undated).

139. Mid-America Regional Council Emergency Rescue, Ambulance Vehicle Inspection Type II, Kansas City, Missouri, (undated).

140. Mills, K., "Future Detection Concepts," IEEE, Transactions on Vehicular Technology, Vol. VT-19, No. 1, February 1970, pp. 43-49.

141. Milwaukee County Department of Public Works, Highway Division, Proposal for Towing and Roadside Service on Milwaukee County Expressways, Milwaukee, Wisconsin, February 1970.

142. Minnesota Inter-County Council, Helicopter Ambulance Service to Emergencies, Final Report, Contract No. DOT-HS-800495, March 31, 1971.

143. Mississippi State University, Division of Research, College of Business and Industry, Extension of Project CARE-SOM (Coordinated Accident Rescue Endeavor, State of Mississippi), Final Report, Contract No. DOT-HS-019-1-020, June 1971.

144. Missouri State Highway Patrol, "Accident Investigation," General Order VI-6-42, Jefferson City, Missouri, November 22, 1972.

145. Missouri State Highway Patrol, "CB Radio Policy," General Order X-2-97, Jefferson City, Missouri, August 1, 1975.

146. Missouri State Highway Patrol, Manual on Collecting and Recording Data on the Missouri Uniform Accident Report for Motor Vehicle Traffic Accident Files, Jefferson City, Missouri, (undated).

147. Molnar, D. E., C. B. Shields, and D. D. Robinson, Driver-Aid Systems for Controlled Access Rural Highways, Final Report, Phase I, Battelle Memorial Institute, Columbus Laboratories, Columbus, Ohio, February 19, 1968.

148. Moore, C. D., Report on the Michigan Emergency Patrol, A Major Motorist Communication Project Utilizing Citizen Band Radio, presented at the Transportation Research Board Meeting, Washington, D.C., January 20, 1976.

149. Moore, C. D., Jr., Summary and Comment on FCC Docket No. 20120, University of Michigan, Ann Arbor, Michigan, January 30, 1975.

150. Motorola, Motorcall Highway Emergency Radio System, Schaumburg, Illinois, (undated).

151. Murphy, J. F., "Roadside Motorist Call Boxes Insure Emergency Aid and Safety," Rural and Urban Roads, March 1974.

152. Nadan, J. S. and Wiene, R., "Aid to Disabled Motorists: Responsive Electronic Vehicular Instrumentation System," Transportation Research Record No. 536, Washington, D.C., 1975.

153. National Academy of Engineering, Communications Technology for Urban Improvement, Washington, D.C., June 1971.

154. National Academy of Sciences, A Study of Transportation of Hazardous Materials, Washington, D.C., May 1969.

155. National Academy of Sciences, "Systems for Responding to Freeway Accidents, An Annotated Bibliography," Highway Research Board, Bibliography 53, 1971.

156. National Cooperative Highway Research Program, Motorists' Needs and Services on Interstate Highways, Report No. 64, 1969.

157. National Cooperative Highway Research Program - Synthesis of Highway Practice, Motorist Aid Systems, Report No. 7, 1971.

158. National Highway Transportation Safety Administration, Use of the Citizens Radio Service for Transportation Safety, Report to the Deputy Secretary, U.S. Department of Transportation, March 1975.

159. Neely, W., "Radio S-E-M-I," Playboy Magazine, November 1975.

160. Nichols, Captain Patrick, San Antonio Police Department, telephone conversation, March 2, 1976.

161. Nivin, E. A., Freeway Procedural Manual, District Five, Arizona Department of Public Safety, Phoenix, Arizona, December 1974.

162. North Dakota State Highway Department, Debris Hazard Control and Cleanup Manual, Bismarck, North Dakota, (undated).

163. Olson, P. L., Citizen Participation to Improve Highway Safety - Phase I, Task I Report, Contract No. DOT-HS-5-01184, Ann Arbor, Michigan, (undated).

164. Organization for Economic Cooperation and Development, Research on Traffic Corridor Control, Paris, France, April 18, 1975.

165. Pavlinski, L. A., "Public Safety Responsiveness--On-Site Management of Highway Incidents," Traffic Quarterly, Columbia University Press, New York, New York, April 1970.

166. Payne, H. J., et. al., Development and Testing of Incident Detection Algorithms, Volume 2, "Research Methodology and Detailed Results," April 1976, Report No. FHWA-RD-76-20. (A report prepared by Technology Service Corporation for FHWA.)

167. Peacock, J. M., Planning the Telephone Highways, presentation at the annual meeting of the American Association of State Highway Officials, Los Angeles, California, November 14, 1973.

168. Peat, Marwick, Livingston & Co., Motorist Aid System for Rural Freeways, State of Illinois, Washington, D.C., July 1968.

169. Perkins, C., "Beltway Patrol Proves Its Value," The Gazette, Alexandria, Virginia, January 19, 1976.

170. Pittman, Mary Ann And Roy C. Loutzenheiser, "A Study of Accident Investigation Sites on the Gulf Freeway," Texas Transportation Institute, August 1972.

171. Pogust, F., A. Kuprijanow, and H. Forster, Means of Locating and Communicating with Disabled Vehicles, National Cooperative Highway Research Program Report No. 6, Washington, D.C., 1964.

172. Police Traffic Services, Basic Training Program - Student Study Guide, National Highway Traffic and Safety Administration, Washington, D.C., October 1972.

173. Preston, A. R., "A Pox on Beltway Boxes," The Evening Star and Daily News, Washington, D.C., August 21, 1972, p. B-4.

174. Quinn, C. E., "A Highway Communications System for the Motorist: The Case for Two-Way Radio," Highway Research Record No. 402, Washington, D.C., 1972.

175. Radio Shack, 1976 Electronics Catalog, Cat. No. 263, Fort Worth, Texas, 1976.

176. Railway Systems and Management Association, Handling Guide (brochure) - For Potentially Hazardous Materials, Chicago, Illinois, 1975.

177. Renner, J. J., and A. D. Owen, A Motorist Radio Service, Advanced Technology Systems, Inc., Arlington, Virginia, January 1972.

178. Reynolds, Major C. Les, Police Department, Springfield, Missouri; Lieutenant D. E. Wood, Police Department, Greensboro, N.C.; and Lieutenant Michael Griffin, Connecticut State Police, telephone conversations, February 27, 1976, March 8, 1976, and February 4, 1976, respectively.

179. Richard, C. L. and K. Bushnell, "Television Equipment for Traffic Surveillance," Highway Research Record No. 10, Washington, D.C., 1963.

180. Ritch, G. P., "State-of-the-Art of Motorist Aid Systems," Texas Transportation Institute Research Report No. 165-17, June 1975.

181. Roberts, E. I. and D. L. Hoffman, Motorist Service Vehicle System Feasibility Study for Interstate 5, Washington State Department of Highways, Bellevue, Washington, March 1973.

182. Romano, Donald, Chicago Emergency Patrol, interview, November 17, 1975.

183. Roper, D. H., et al., "Alternate Route Planning: Successful Incident Traffic Management," Transportation Research Board Special Report No. 153, Washington, D.C., August 1974.

184. Rosenblatt, A., "Many Motorist Call Boxes Don't Work," Miami Herald, Miami, Florida, March 20, 1975.

185. Roth, W. J., "Rural Freeway Emergency Communications for Stranded Motorists: Final Phase Report," Highway Research Record No. 358, Washington, D.C., 1971.

186. Roth, W. J., "Study of Rural Freeway Emergency Communications for Stranded Motorists," Highway Research Record No. 303, Washington, D.C., 1970.

187. Sakasita, M. and A. D. May, "Development and Evaluation of Incident Detection Algorithms for Electronic-Detector Systems on Freeways," Transportation Research Record No. 533, Washington, D.C., 1975.

188. Sands, L. G., 101 Questions and Answers About AM, FM, and SSB, Howard W. Sams & Co., Inc., New York, New York, 1972.

189. Silversmith, Paul, Highway Associate Engineer, Connecticut Department of Transportation, interview, February 4, 1976.

190. Smith, Major Robert L. and Lieutenant C. J. Carreno, Tampa Police Department, interview, March 11, 1976.

191. Smith, R. D. and D. A. Espie, Guidelines for Police Services on Controlled Access Roadways, Research and Development Division, International Association of Chiefs of Police, Washington, D.C., December 1967.

192. Smith, R. D., B. Keenan, R. Shamberger, and J. A. Karmasck, Police Traffic Responsibilities, prepared for National Highway Safety Bureau, Washington, D.C., July 1969.

193. Smith. R. D. and T. N. Tamhirri, "Direct Costs of California State Highway Accidents," Highway Research Board 225, 1968.

194. Smith. S.S., "CB Radio Policy," General Order X-2-97, Missouri State Highway Patrol, Jefferson City, Missouri, August 1, 1975.

195. Smith, S. S., Cooperation Through Communication - A Position Paper, Missouri State Highway Patrol, Jefferson City, Missouri, May 1975.

196. Smith, Wilbur & Associates, Traffic Crash - Volume I, Control and Cleanup, for the Highway Safety Division of Virginia, Richmond, Virginia, 1972.

197. Southern Railway System, "Southern's Go-Team," Ties-The Southern Railway System Magazine, Washington, D.C., Vol. 24, No. 3, May-June 1970.

198. Sperry Systems Management Division, A Systems Approach to Accident Reduction on the Van Wyck Expressway - Final Report, Great Neck, New York, October 1971.

199. Standard Parts Corporation, Emergency Brake Manual, Richmond, Virginia, (undated).

200. Stephens, B. W., "Some Principles for Communicating With Drivers Through the Use of Variable Message Displays," Highway Research Board Special Report 129, 1971.

201. Streich, E. R., J. F., Knudson, and B. D. Miller, Highway Debris Hazard Control and Cleanup Study: Volume I - Technical Report, Volume II - Debris Incident Case Studies, Volume III - Planning and Operations Handbook prepared for the National Highway Traffic Safety Administration, March 19, 1971.

202. Stucker, D., "Expressway Patrol," Louisville Automobile Club Bulletin (AAA), Louisville, Kentucky, February 1976.

203. Sullivan, Col. John J., Virginia Highway Courtesy Patrol, interview, January 6, 1976.

204. Sullivan, H. W., and R. C. Blossom, Operation 500: Background Report, Final Report II, State of California, Department of California Highway Patrol, Sacramento, California, January 1970.

205. Systems Development Corporation, Highway Debris Hazard Control and Cleanup Volume I-Technical Report, Contract No. FH-11-7274, Washington, D.C., March 1971.

206. Systems Development Corporation, Highway Debris Hazard Control and Cleanup Volume II-Debris Incident Case Studies, Contract No. FH-11-7274, Washington, D.C., March 1971.

207. Systems Development Corporation, Highway Debris Hazard Control and Cleanup Volume III-Planning and Operations Handbook, Contract No. FH-11-7274, Washington, D.C., March 1971.

208. Tacoma, City of, Ordinance No. 19452, Tacoma, Washington, (undated).

209. Tacoma, City of, Rules and Regulations Establishing Specifications for City of Tacoma Contract Relating to Towing and Storage Services, Tacoma, Washington, (undated).

210. Tampa Police Department, City of Tampa Police Department Rotation Wrecker Regulations, Tampa, Florida, (undated).

211. Tampa Police Department, Rotation Wrecker Complaint File, Tampa, Florida, November 1, 1975.

212. Tampa, City of, Wrecker Ordinance, Tampa, Florida, October 1, 1975.

213. Texas Transportation Institute, "Cost Effectiveness Evaluation of Freeway Courtesy Patrols in Houston," Research Study Number 2-18-72-165, Texas A&M University, College Station, Texas, October 1974.

214. The Associated Public-Safety Communications Officers, Inc., The Public Safety Communications Standard Operating Procedure Manual, New Smyrna Beach, Florida, June 1, 1974.

215. Tignor, S. C., State-of-the-Art on Equipment for Servicing Freeway Incidents, Interim Report of the Task Group on Incident Detection and Response (unpublished), Freeway Operations Committee of Transportation Research Board, January 1974.

216. Trabold, W. G. and G. H. Reese, "Performance of Volunteer Monitors Using Citizens Band Radio for a Highway Communications Service," Transportation Research Record No. 495, Washington, D. C.. 1974.

217. Tressa, F. and P. Sielman, Single Frequency Highway Communications System, Airborne Instruments Laboratory, Deer Park, New York, February 1972.

218. Tweedie, R. W. and J. E. Taylor, "An Evaluation of the Northway Emergency Telephone System, Highway Research Record No. 202, Washington, D.C. 1967.

219. U.S. Army, Office of the Secretary, Office of Civil Defense, Civil Defense and The Public-An Overview of Public Attitude Studies, Washington, D.C., October 1971.

220. U.S. Department of Health, Education and Welfare, Compendium of State Statutes on the Regulation of Ambulance Services, Operation of Emergency Vehicles and Good Samaritan Laws, Washington, D.C., June 1969.

221. U.S. Department of Health, Education and Welfare, Emergency Health Services-Selected References, Rockville, Maryland, April 1972.

222. U.S. Department of Health, Education and Welfare, Model Act for Emergency Medical Services, Washington, D.C., May 1972.

223. U.S. Department of Transportation (FHWA), Federal Laws, Regulations, and Material Relating to the Federal Highway Administration, Washington, D.C., April 1975.

224. U.S. Department of Transportation (FHWA), Federal-Aid Highway Program Manual, Transmittal 145, Washington, D.C. July 3, 1975.

225. U.S. Department of Transportation (FHWA), Identification and Surveillance of Accident Locations - Highway Safety Program No. 9, Washington, D.C., February 1974.

226. U.S. Department of Transportation (NHTSA), Annual Work Program-Highway Safety Program Manual, Volume 103, Washington, D.C., February 1972.

227. U.S. Department of Transportation (NHTSA), Communications, Guidelines for Emergency Medical Services, Government Printing Office, 1972.

228. U.S. Department of Transportation (NHTSA), Comprehensive Plan and Annual Work Program-Highway Safety Program Manual, Volume 102, Washington, D.C., September 1972.

229. U.S. Department of Transportation (NHTSA), Debris Hazard Control and Cleanup-Highway Safety Program Manual No. 16, Washington, D.C., January 1975.

230. U.S. Department of Transportation (NHTSA), Dispatcher - Emergency Medical Technician Training Course, Washington, D.C., November 1972.

231. U.S. Department of Transportation (NHTSA), Highway Safety Program Manual No. 11-Emergency Medical Services, Washington, D.C. April 1974.

232. U.S. Department of Transportation (NHTSA), Police Traffic Services-Highway Safety Program Manual No. 15, Washington, D.C., December 1974.

233. U.S. Department of Transportation (NHTSA), Statewide Highway Safety Program Assessment-A National Estimate of Performance, Washington, D.C., July 1975.

234. U.S. Department of Transportation, (NHTSA) Training Program for Emergency Medical Technican Dispatcher: Course Guide, October 1975.

235. U.S. Department of Transportation, Office of the Secretary and Office of Hazardous Materials, Emergency Services Guide for Selected Hazardous Materials, Washington, D.C., 1974.

236. Virginia Division of Traffic Safety, Summary of Accident Data 1974, Richmond, Virginia, 1975.

237. Virginia Highway Courtesy Patrol, The Rules and Regulations, Falls Church, Virginia, (undated).

238. Washington State Department of Highways, District 7, Interstate 5 Motorist Vehicle System Feasibility Study, March 1973.

239. Washington State Patrol, Debris and Hazardous Material Cleanup and Control, Seattle, Washington, (undated).

240. Waters, J. M., "The Jacksonville EMS: A Model for the Seventies," Transportation Research Board Special Report No. 153, Washington, D.C., August 1974.

241. Weston, Paul B., The Police Traffic Control Function, 2nd Edition, Charles C. Thomas Publisher, Springfield, Virginia, 1971.

242. Wilshire, Roy L. and Charles J. Keese, Effects of Traffic Accidents on Freeway Operations, Texas Transportation Institute, Bulletin No. 22, 1963.

243. Wilson, Chief, Deputy Chief for Dispatch, Los Angeles Fire Department, telephone conversation.

244. Wilson, E. M., and J. S. Matthias, "Air Medical Evacuation and Surveillance System," Transportation Research Record No. 498, Washington, D.C., 1974.

245. Wisconsin Department of Transportation, Division of Highways, Emergency handling of Post-Accident Problems, Madison, Wisconsin, (undated).

246. Wisconsin Department of Transportation, Machinery Agreement - 1976, Milwaukee, Wisconsin, 1976.

247. Wisepart, I. S., "Designing the First FLASH Installation," Highway Research Record No. 3030, Washington, D.C., 1970

248. Wisepart, I. S., "FLASH: A Disabled Vehicle Detection System," IEEE Transactions on Vehicular Technology, Volume VT-19, No. 1, February 1970.

249. Wisepart, I. S., et al., Reporting of Disabled Vehicles by Cooperative Motorists, Airborne Instrument Laboratory, Deer Park, New York, May 1967.

250. Wood Lieutenant D.E., Police Department, Greensboro, N.C. telephone conversation, March 8, 1976.

251. Wyoming Highway Department, Debris and Hazardous Materials- Control and Cleanup, Cheyenne, Wyoming, (undated).

252. Zimowski, R. F., Information About CALTRANS Major Incident Response Team, Los Angeles, California, March 18, 1975.

253. Zimowski, Robert and Richard Murphy, CALTRANS, Los Angeles California, interview, January 12, 1976.

254. Zito, T., "There's a Smokey Shooting Pictures Near Exit 14," The Washington Post, Washington, D.C., November 27, 1975.

APPENDIX A

ORGANIZATIONS INTERVIEWED (LISTED BY STATE)

1. ARIZONA
   Arizona Department of Public Safety - Phoenix

2. CALIFORNIA
   California Department of Transportation
   Los Angeles Police Department
   California Highway Patrol - Sacramento and Los Angeles

3. COLORADO
   Denver General Hospital, Emergency Services Administration
   Denver Police Department
   Colorado State Patrol - Denver

4. CONNECTICUT
   American Sign and Indicator Co. - Hartford
   Connecticut Department of Transportation - Hartford
   Motor Transport Association of Connecticut
   Connecticut State Police

5. DISTRICT OF COLUMBIA
   Washington, D.C., Police Department
   Kings Motor Company
   Pepco
   International Bridge, Tunnel and Turnpike Association
   ALERT National Headquarters
   General Services Administration
   Manufacturing Chemists Association
   Insurance Institute for Highway Safety
   Law Enforcement Assistance Administration
   Association of American Railroads
   Bureau of Motor Carrier Safety
   National Highway Traffic and Safety Administration
      Office of Driver and Pedestrian Safety
      Office of Financial Management
      Office of State Planning
      Office of Driver and Pedestrian Programs
   Federal Highway Administration
      Office of Highway Safety
      Office of Traffic Operations
      Traffic Systems Division

6. FLORIDA
   Clearwater Police Department
   St. Petersburg Traffic Department
   Suncoast AAA
   Tampa Police Department
   Tampa Traffic Department
   Florida Department of Transportation
   Clearwater Traffic Department
   Bill Curry's Ford-Tampa

7. GEORGIA
   Atlanta Police Department
   Georgia Department of Transportation - Atlanta
   DeKalb County Police Department - Decatur
   Georgia Department of Public Safety - Atlanta
   Metropolitan Atlanta Regional Transportation Authority - Atlanta

8. ILLINOIS
   Best Barricade Co. - Palatine
   Illinois Department of Transportation
   Illinois State Toll Highway Authority
   REACT International, Inc. - Chicago
   Isringhausen Railroad Specialists - Jerseyville
   Railway Systems and Management Association - Chicago
   National Association of Automotive Mutual Insurance Companies - Chicago
   National Association of Independent Insurers - Chicago

9. KANSAS
   Kansas City, Kansas Police Department

10. KENTUCKY
    Louisville Police Department
    Louisville Automobile Club (AAA)

11. MARYLAND
    Maryland State Police
    Prince George's County Fire Department
    Maryland Department of Transportation
    Bowie Fire Department
    Baltimore County Fire Department
    Woodlawn Police Station - Baltimore
    Baltimore County Police Department
    International Association of Chiefs of Police - Gaithersburg
    NHTSA Regional Administrator - Baltimore
    Police Headquarters - Baltimore Harbor Tunnel

12. MICHIGAN
West Side Iron Works, Inc. - Grand Rapids
Michigan Emergency Patrol - Detroit
University of Michigan - Ann Arbor
Michigan Department of State Highways and Transportation - Detroit

13. MINNESOTA
Minnesota Highway Department - St. Paul
3-M Company - Minneapolis
Minnesota State Patrol - Minneapolis
Honeywell - Minneapolis

14. MISSISSIPPI
Jackson Police Department
Mississippi State Highway Department - Jackson

15. MISSOURI
Missouri State Highway Patrol - Jefferson City
Kansas City, Missouri Police Department
Scrogham Ambulance - Kansas City, Missouri
Mid America Regional Council Emergency Rescue - Kansas City
Springfield Police Department

16. NEBRASKA
Omaha Traffic Department
Nebraska Department of Roads - Omaha

17. NEW YORK
R. E. Dietz Co. - Syracuse
American Insurance Association - New York
New York State Police-Troop "T" - Albany
Buffalo Police Department
New York Department of Transportation - Albany

18. NORTH CAROLINA
Radiator Specialists, Co. - Charlotte
Greensboro Police Department

19. OHIO
Winkomatic Signal Co. - Avon Lake
Dura Corporation - Toledo
Cleveland Police Department
American Automobile Association - Cleveland
Youngstown Police Department

20. OKLAHOMA
VEPED Traffic Controls, Inc. - Oklahoma City

21. PENNSYLVANIA
EMS Regional Administrator - Philadelphia
LEAA Regional Administrator - Philadelphia
Pennsylvania State Police - Harrisburg
Pennsylvania Department of Transportation - Harrisburg

22. TENNESSEE
Chattanooga Police Department

23. TEXAS
Texas Highway Department - Austin
Forth Worth Traffic Department
Dallas Police Department
Texas Department of Public Safety - Austin
San Antonio Traffic Department
San Antonio Police Department

24. VIRGINIA
Virginia State Highway Patrol - Engleside
Richmond-Petersburg Turnpike Authority - Richmond
Richmond Metro Authority - Richmond
Davis Industries, Inc. - Arlington
Henry's Wrecker Service - Merrifield
Virginia Highway Courtesy Patrol - Falls Church
Virginia Department of Highways and Transportation - Hampton and Falls Church

25. WASHINGTON
Washington State Highway Commission - Seattle and Olympia
King County Traffic Department - Seattle
King County Police Department - Seattle
Seattle Traffic Department
Seattle Fire Department
Bill's Towing and Garage, Inc. - Tacoma
Washington State Patrol - Bellevue
Tacoma Police Department

26. WISCONSIN
Milwaukee County Sheriff's Department
Wisconsin Department of Highways - Madison
Milwaukee County Highway Department

APPENDIX B
PATROL COSTS

TABLE B.1
COST BY PATROL TYPE

Patrol Type	Hours of Operator	Labor Costs [1] Per Person Per Year	Vehicle [2] Costs Per Shift Per Year
Police	8	\$10,000 – \$14,000 [3]	\$3,270 – \$4,500 [4]
Service or Courtesy Patrol			
a. For Service Vehicle-Pickup	8	\$10,000 – \$18,000 [5]	\$3,100 – \$3,600 [6]
b. For Service Vehicle-Tow Truck	8	\$10,000 – \$18,000 [7]	\$6,240 – \$20,800 [8]
c. For Service Motorcycle	8	\$10,000 – \$14,000 [9]	\$ 900 – \$2,300 [10]
Aircraft [11]			
a. Helicopter	4	TOTAL	\$112,320 [12]
b. Fixed Wing	4	TOTAL	\$ 26,000 [13]

NOTES ON FOLLOWING PAGES

NOTES:

[1]Labor costs represent the cost per year of assigning one individual to one shift for 2,080 hours per year. However, to provide for vacation, sickness, and other types of leave, it will be necessary to either provide a back-up capability or a less comprehensive patrol coverage. To convert this figure to 24-hour, 7-day service, it is necessary to multiply the cost by about 5. This factor indicates that after taking sick leave, vacations, holidays, etc., into account that there are 224 days (1,792 hours) of work available per year (8,760 hours) per policeman (171). This factor, 8760/1792, is about 4.8. Others have used 4.64 and 5. The same factor can be used for service patrols.

Costs for labor for police patrol can vary with respect to experience, which is reflected in the costs. However, costs for service patrols can vary in other respects also. Policy can dictate that two people man each vehicle, that each individual be a professional traffic engineer, or that overtime or shift splitting fees be paid. Several of the points in the cost range reflect these policies.

Costs for years prior to 1976 are updated by 9.0 percent per year (compounded), based upon an average of the consumer price index.

[2]Vehicle costs per shift must reflect the policy of vehicle pooling. For example, if the vehicle belongs to a pool, then it is available for duty at all times. However, if it is assigned to an individual (as are many state police cruisers), then the vehicle is only available when the man is available. Thus, the vehicle fleet would have to be inflated in a manner analogous to the manpower requirements. The issue at the heart of the matter is vehicle care. Pool cars tend to cost more to operate than the car assigned to an individual, because an individual typically takes better care of the vehicle because it is his "office" for at least two years.

[3]Typical trooper salaries ranged from \$9,900 – \$12,600 to \$10,692 – \$11,700 with respective benefit packages from 10 to 18 percent. The lower salary represents a rookie while the larger salary represents a man with ten years experience. Both ranges are 1976 costs. The table values reflect benefits, such as insurance, uniform allowance, education cost sharing, etc.

[4]This range is based upon the fact that the Missouri patrol drove over 18 million miles with about 800 cars for an average of about 23,000 miles per car per year with a total operating and replacement cost of 11.9 cents per mile. The Georgia patrol has an 8.5 cents maintenance cost per mile for a \$4,300 vehicle that they drive about 60,000 – 70,000 miles in two years. Salvage value to the Georgia patrol is zero because the vehicles are turned into a state vehicle salvage unit. Thus it costs the patrol about 6.6 cents per mile for replacement cost, if the car is driven 65,000 miles. For discussion purposes a 15 cents per mile cost is used and 30,000 miles of travel per year.

[5]Labor costs for 1973 were $13,520, including benefits (164). An interview with the Virginia Safety Patrol suggested that drivers are paid $3.45 an hour with a 25 percent burden for overhead and benefits. The 25 percent burden was determined from the fact that the total cost of 24-hour, 3-vehicle service for 3 vehicles was $156,959 for FY 1975.

[6]Service vehicle costs were $1.47 per hour, which updates to $1.70 per hour (164). The Virginia Safety Patrol cited a $1.65 per hour cost, which represented a rental cost from the state motorpool. Both costs reflect total maintenance and operation costs as well as total replacement costs. The estimated cost was $1.50 per vehicle-hour for 1976 (17).

[7]Assuming that the skill requirements for a tow vehicle patrol are similar to those required for the service patrol using a pickup truck.

[8]A 1973 cost which was inflated to $3.12 per hour (164). An interview in April 1976 with Henry's Wrecker of Merrifield, Virginia, suggested that the hourly rental of the smallest tow truck commercially available would be $15 per hour. Hamn's Towing of Arlington, Virginia, required $12 per hour. Both include a driver and all vehicle costs. A driver's wage is assumed to be $6.00 per hour in both cases.

[9]This assumes that the same police officer who drives an auto can ride a motorcycle and that the officer does not receive incentive pay for the duty.

[10]These costs are based upon 1974 costs of the Washington, D.C. Police Department and are inflated accordingly. The range is based upon scooters and cycles. However, it is somewhat doubtful that scooters would be used for any service other than rush hour service near ramps.

[11]Implicit in the assumption of the aircraft costs is the fact that the pilot is capable of observing, reporting, and piloting the aircraft. If this assumption is not met, then costs for an observer would have to be included.

[12]Telephone interview with Helicopter Charter Service, 7920 Air Park Road, Gaithersburg, Maryland, March 25, 1976. Interviewer requested the cost of the cheapest service which was $108 per hour. Assume 1,040 hours per year.

[13]Telephone interview with Cole Airways Ltd., Chantilly, Virginia, March 25, 1976. Interviewer requested costs for the cheapest service, which were $25 per hour. Assume 1,040 hours per year.

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